The visualization of natural history museum habitat dioramas by Maltese primary school children

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Abstract

The thesis addresses a relatively under-explored area in this field of study within the socio-constructivist paradigm. The main aim is to investigate how 9-year-old school children visualize habitat dioramas to build a mental model, how they make sense of the dioramas to understand local flora and fauna, and how previous knowledge influences the way they visualise habitat dioramas. Data collected included a first drawing done in class, a second drawing done at the Natural History Museum before and a third following the viewing of the habitat dioramas. Each pupil was interviewed after the respective task to allow for a comprehensive description of the content of the drawings. The children we also asked to produce a web (mind map) and they were also observed as they interacted with the dioramas.

Data was mainly analysed qualitatively through direct examination of the drawings and with the aid of the computer package Atlas.ti. Some general trends emerge in the findings such as animals being more present in drawings than plants. Animal diversity ranks in decreasing order from birds, mammals, arthropods and fish to reptiles, while plants are mainly seeded and ornamental. Generally drawings progress from imaginative in class and before seeing the diorama, to increasingly drawing from observation in the diorama drawings. More significantly, pupils undergo a transformation through their drawings, which may show a change from isolated organisms on a sheet of paper to greater elaboration or better accuracy in placing organisms in habitat. However, others show an opposite transformation or no significant change at all. To a certain extent, children seem to interpret the diorama through the lens of their previously held mental model. What children already know partly influences what they choose to represent, but they also accommodate new knowledge they obtain from the diorama. Dioramas that help recall familiar environments are more likely to capture attention and afford a longer viewing time, thus imparting new knowledge and moulding the child's mental model. Habitat dioramas have the potential to serve as models for learning in Biology and Environmental Education at primary level. An interpretative model for museum settings is proposed, while its potential applications in other areas of science education and limitations are considered.

Declaration

I hereby declare that, except where explicit attribution is made, the work presented in this thesis in entirely my own.

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1 Introduction

'The love for all living creatures is the most noble attribute of man.'
Charles Darwin

'If one really loves nature, one can find beauty everywhere.'
Vincent van Gogh

The research I present here is a first on natural history dioramas and their potential in biological education, one of few out of school studies in Malta, and also a first in the field on the potential of natural history dioramas as biological models for visualization and interpretation of animals and plants. This thesis explores the visual impact of natural history dioramas on primary school children, how they make sense of the dioramas to visualize and understand local flora and fauna and build a mental model and how previous knowledge and culture influence the construction of the mental model.

In chapter 1, I introduce the research and set the scene of the research in the Maltese context, present the natural history dioramas in Malta and their role in Biological learning and state the rationale for the research in this relatively under-explored area within the socio-constructivist paradigm. The research questions are stated at the end of the chapter. In chapter 2, I discuss the literature related to children's understanding of biology, flora, fauna, environment and nature, and studies pertaining to natural history dioramas and their potential for learning in biology. In Chapter 3, I provide the conceptual framework for the research by discussing the literature relating to constructivism, socioculturalism, informal learning, museum learning, perception and mental models, and activity theory. In Chapter 4, I discuss in detail the issues relating to children's drawings, present the pilot study and explain in detail the data collection methods for the empirical work and qualitative/semi-quantitative analysis adopted using Atlas.ti. In Chapter 5, I present the results of the analysis of drawings, webs, interviews and audio data collected. In Chapter 6, I discuss the main findings relating to understanding of flora and fauna by Maltese children, their interpretation of the dioramas and I present the novel theoretical model. In Chapter 7, I discuss the limitations of the research and methods, the main conclusions from the data, the contribution to knowledge and give my main recommendations for learning and further research.

By the manner in which they represent natural settings, habitat dioramas can serve as important learning tools for visitors of all ages. For many years, people in Europe and the United States have been awestruck by the uniqueness of these exhibits, but habitat dioramas are only a recent addition to the Natural History Museum here in Malta. Like other researchers (Cotumaccio, 2015; Dunmall, 2015; Garibay and Gyllenhaal, 2015; Livingstone, 2015; Reiss, 2015; Scheersoi, 2015; Tinworth, 2015; Tunnicliffe; 2015), I believe in the value of natural history dioramas as resources for biological learning. In this research, I look into the potential of natural history dioramas to aid nine-year-old school children in learning about local flora and fauna of the Maltese archipelago. I also address the curricular shortcomings and argue for the education role of museums and their place in the science curriculum. Unlike the United Kingdom and the United States, Malta does not have a tradition of collaboration between museums and schools. In recent years, Heritage Malta (an organisation that is responsible for all state owned museums) has introduced basic educational programs, but only in a very limited number of museums.

1.1 My interest in Biology and learning

The American evolutionary biologist Stephen Jay Gould (1941-2002) was five years old when his father took him to the Hall of Dinosaurs in the America Museum of Natural History, where he first encountered *Tyrannosaurus rex*. Gould later recalled "I had no idea there were such things - I was awestruck". It was in that moment that he decided to become a paleontologist (Green, 1986: 113).

Reading this biographical article on Stephen Gould brought back to my mind vivid memories of my own childhood, in particular my outdoor experiences in nature. My father was tenant of a small piece of land where he cultivated a few crops as a hobby. Almost every weekend, I would be more than glad to accompany him and lend a helping hand. I recall many happy days in those open field spaces, where I could run among the wild flowers, grasses and trees or just sit quietly on a stone and listen to the birds. These experiences probably had a crucial influence on me, instilled in me a love for nature and motivated my enthusiasm for the biological sciences.

My earliest childhood recollection of a museum visit is during a school trip to the Museum of Fine Arts in Valletta. When I was sixteen years old, I travelled to Munich on a student exchange and there I had the memorable opportunity to visit and experience the wonders of the famous Deutsches Museum. This was probably what rekindled in me a keen interest in museums. Prior to the advent of the Deutsches Museum and later the emergence of hands-on science teaching in the 1960s, the educational vocation of museums was not so well defined and clear as in present times. Today, curators and museum educators fully recognise the educational role of museums, but argue on how museum should fulfil this role (Crane et al, 1994).

My early interest in museums was later complemented by my studies in Biology and eventually my career as an educator. This research on understanding of local animals and plants fitted in well with my professional interest in Biology and enhanced my enthusiasm for the subject. Doing research is different from teaching and leads to self-reflection on the ideas and practices of learning one tends to get used to after many years of teaching. The research also stimulated me to encourage my students to observe and study local flora and fauna with greater interest.

Professionally, I am a lecturer in Biology at the University of Malta Junior College that welcomes over three thousand, 16-18 year old students from all over the island. My interest in Biology originated from my childhood encounters with nature. My enthusiasm for the subject was amplified in school through my Biology lessons and firmly consolidated by my undergraduate studies. I was primarily motivated to enter the doctorate by my academic interest in the Biological sciences and secondly by a desire and belief that I can make a valid contribution to science education as a researcher as well as a teacher. I felt that the time was right to concentrate on the reflective as well as philosophical aspect of science education. I believe that in Maltese schools we have much to do to improve the way science is being presented and taught, particularly at primary level. Rote learning is highly predominant, active student learning is not sufficiently encouraged and out-of-school learning experiences are very limited. I firmly believe that no contribution may be reliable or credible unless it is grounded in thorough research. Although I have, in the past decade, worked in science education at post secondary level, my main research interest now is in early science particularly the learning of biology in non-formal settings.

My empirical research is based at the habitat dioramas found at the natural history museum in Malta. The rationale for choosing to research these museum settings is mainly because they are predominantly naturalistic exhibits that focus on biology and the environment while also showing local cultural aspects. The work done there has offered me opportunities to primarily work with young children and learn how they react to these settings and how their observations impacts on learning about animals and plants. I have proceeded from practice to research-informed practice that enriched my professional outlook and performance. Research of this kind should have important implications on early Biological and Environmental educational in Malta and the way learning about animals and plants is affected in our primary schools. Being a very small archipelago, Malta has limited flora and fauna, which is under constant threat from sustained urbanisation. Children in Malta have limited opportunities for direct contact with the flora and fauna in the wild that Malta's local habitats have to offer. Our educational system remains highly school centred with limited out-of-school activities occurring during the scholastic year, although this would vary from one school to another. Many children depend on their parents' interest and initiatives to be able to experience the diversity in flora and fauna of the typical Mediterranean habitats of the Maltese islands.

Increasing urbanisation and declining populations of various species have reduced opportunities for children to directly experience organisms in the wild. This raised worries amongst society that the next, largely urbanised generation will have little knowledge and interest in biota (Huxham et al, 2006:9; Louv, 2008: 68; Medin and Atran, 2008: 36-37). Malta with its limited endemic biota and over a third of its surface area (316 km^2) occupied by building, offers limited opportunities for engaging with nature. The habitat dioramas showing conceptual dioramas of local natural history habitats at the NHM in Malta are an underutilised educational resource. This is mainly due to the ethos of out of school visits and the apparent lack of attention afforded by most schools and lack of emphasis on informal learning in teacher training. Dioramas may serve as an early stimulus for children to recognise and become further familiar with their local biodiversity. The diorama experience may encourage children to look closer around them and may be notice an organism or two. Although it is always desirable to have direct exposure to organisms in the natural world (Hamilton et al, 1991: 16), dioramas can be valuable to the urban community in constructing understanding of the different habitats and interactions between organisms (Tunnicliffe, 2005: 24). Habitat dioramas are both an untapped educational resource (Borg, 2009) and a valuable resource for museum education (Marnadinia and Oliveria, 2009).

1.2 The significance of early naturalistic influences

Through the years, many eminent naturalists have been positively influenced by their childhood experiences in direct contact with nature. The following are a few examples of personalities who had early enlightening experiences and later went on to become naturalists who contributed to our knowledge about nature. Theodore Roosevelt and his naturalist associate John Burroughs, who in their own way created and nurtured a movement from 1903 to 1907 when the US witnessed a major environmental awakening. Burroughs was raised as a farm boy on the hills of New York's Catskills. His youthful experiences in the fields, woods and rolling terrain had a huge influence on his thinking and activities. Roosevelt came from a family of merchants and from early childhood had a deep interest in natural history which he studied with enormous seriousness and enthusiasm, and which he never abandoned in spite of his political career (Lutts, 2001: 10).

Ernest Ingersoll (1852-1946) was an American shellfish biologist and like many naturalists of that era, his principal amusement as a boy was searching through the woods and fields around Monroe (Michigan) for rare and curious natural history specimens. Carl Linnaeus was a Swedish Naturalist (1707-1778) born in Rashult and raised in Stenbrohult where as a young boy he possessed his own garden, which, he later described as "inflamed my soul with an unquenchable love of plants" (Kilpatrick, 1998:427). Charles Robert Darwin (1809-1882) already exhibited a flair for natural history and collection of natural objects when he joined his day school in 1817 at the age of eight years (Vendramini, 2005). The American Naturalist and Biologist Edward Osborne Wilson (1929-) became a naturalist at an early age and after injuring his right eye, he learned to examine insects closely with his left eye. Like A. Russell Wallace, T.H. Huxley and other British scientists of the time, the English naturalist Henry Walter Bates (1825-1892) had no formal education in science, and left school aged 12. He came from a literate middle-class family and taught himself mainly by reading (like Wallace, Huxley and Herbert Spencer, he was an auto-didact). English ornithologist John Gould (1804-1881) was the son of a gardener and as a boy probably had a scanty education. The young Gould started training as a gardener and was employed under his father who was foreman in the Royal Gardens of Windsor.

English Biologist Thomas Henry Huxley (1825-1895) was one of the great autodidacts became perhaps the finest comparative anatomist of the second half of the nineteenth century. Huxley had little schooling, and taught himself almost everything he knew. Thomas left school at 10, after only two years of formal schooling. Later on, as a young adult, he made himself an expert first on invertebrates, and later on vertebrates, all self-taught (Clodd, 2013). Better known as the father of genetics, Czech monk Gregor Mendel (1822-1884) lived and worked on a farm which had been owned by the Mendel family for at least 130 years. During his childhood, Mendel worked as a gardener, studied beekeeping. English Biologist Sir Julian Sorell Huxley (1887-1975) showed an early interest in nature and was given lessons by his grandfather, Thomas Henry Huxley.

In an interview that I very recently followed on T.V, Joe Sultana, a prominent Maltese ornithologist, recalled how one of his teachers in primary school would take the whole class in the yard to observe flocks of birds in flight over the school (interviewed by Saviour Balzan: 2010). In another interview, NatureTrust (Malta) president Vince Attard recounted how his secondary school Biology teacher had inspired him to become actively involved in environmental conservation at the age of 11 and explained that;

> *"As a child, I would often visit places like Chadwick Lakes with friends in order to just enjoy nature" (Carville: 2010).*

Chawla (1998) reports pioneer research by Tanner and Peterson who found that conservationists were mostly influenced by childhood experiences in natural areas, frequent contact with habitats and outdoor activities such as family vacations, childhood play, youth group camps and hunting or fishing (Chawla, 1998: 371-372). Later studies reported were those by Palmer, James and Gunderson with environmental educators, Peters Grant with volunteer marine workers, Sward and Chawla with environmental conservation planners, Myers with undergraduates, McKnight with college seniors of environmental studies, Sivek and Hungerford with members of fishing, hunting and trapping clubs (cited in Chawla, 1998: 373-380). In all cases, the subjects were mostly influenced by childhood outdoor activities in the wilderness, childhood natural areas, outdoor exposure and positive outdoor experiences of natural areas. Habitat dioramas may stimulate and encourage this early childhood exploration of nature and local habitats.

Palmer conducted three separate studies with environmental educators in various European and non-European countries. In the first, the childhood nature/outdoor category was ranked in the first three places by subjects from the United Kingdom, Slovenia and Greece. Participants were asked to write an autobiographical statement identifying those influences and experiences that led to their environmental concern. Furthermore, participants were asked to state what they considered to be their most significant life experiences (Palmer et al, 1998: 440). The second study provides an overview of data obtained from nine countries. A direct experience of the natural world affected over half the respondents and was the most influential group of factors. It was also clear that the most important single factor by far was childhood experiences of nature (Palmer et al, 1998: 453). In the third study, educators in the United Kingdom, Australia and Canada all ranked first childhood nature/outdoor experiences as a single influencing factor (Palmer et al, 1999: 198).

These accounts indicate that early experiences with nature develop a love and interest for living organisms and the natural environment in general. They also seem to imply a link between childhood exposure to nature and future roles as biologists and naturalists. Early ‘experiencing’ or ‘engaging with’ nature refers to direct contact with nature, being inquisitive about anatomical characteristics and phenomena following observation and noting or touching things. There is also a sense of wonder about nature. Children need exposure to nature and need to be taught how to look and find out things. School curricula have a role and responsibility to provide learning opportunities of this type. I feel that appreciating nature is so important for the personal enrichment it provides to the child and enjoyment while viewing biodiversity. If the child is able to appreciate nature, there is a greater probability he/she will strive to protect it and avoid activities that harm ecosystems.

Can natural history dioramas provide a similar enriching experience to that offered by direct contact with nature? I do not think that a natural history diorama can ever replace an actual natural setting, but I do believe they aid in learning on animals and plants. It may impart a renewed interest in local flora and fauna especially in the case of children confined to urban areas that do not have many opportunities to encounter authentic nature. The natural history museum in Malta has five habitat dioramas that present common species of animals and plants in typical snapshots of local ecosystems and urban areas.

1.3 Maltese ecology and natural history

In spite of the very small geographical size, the Maltese archipelago harbours 1,100 plant species and 2,200 animal species. There are four typical Mediterranean ecosystems of the Maltese Islands namely: Steppe, Garigue, Maquis and Woodland. The *Garigue* is the most common habitat, characterised rocky land with very little soil on large expanses of exposed limestone and herbaceous/aromatic vegetation of low growing shrubs such as the typical Mediterranean thyme. In Malta, there are virtually no natural woodlands with the only exception of “Buskett”, a 16th century semi-natural plantation of common trees including Aleppo pines, Evergreen oak, Olive and Carob.

The fauna living in these habitats include a variety of snails, wide range of insects, a few crustaceans such as the woodlouse, a few spiders and scorpions, a few reptiles such as the wall lizard (four sub-species known), many birds most of which are migratory and a few small sized mammals the largest being the wild rabbit (Sultana & Falzon, 2002: 23-24). A selection of animal and plant specimens from these ecosystems are displayed in the habitat dioramas at the Natural History museum enabling urban dwelling children to become familiar to a limited extent with the biology of their country.

Originally, the seat of the University and later the palace of Grand Master de Vilhena (1722-36), the National Museum of Natural History of Malta was established in 1973. A series of small but life sized habitat dioramas installed in the museum of natural history in Malta offer a diverse representation of local habitats and ecosystems. The five dioramas are typical representations of a rural back yard, a field with rubble wall, a deep valley, a sandy beach and a fortification. These are snapshots of common Maltese habitats that offer an occasion to viewers to discover the animals and plants normally inhabiting these places. Habitat dioramas are three-dimensional museum displays presenting imitations of biological landscapes. These displays typically show preserved animals in their natural foreground with freeze-dried or modelled flora of some form set against a painted background. The diorama's integrated montage of animals with their surroundings is a means of bringing natural history to 'life', but at the same time exposing human attitudes toward nature and so also perform a function in the cultural construction of our world (Wonders, 2003: 89). The dioramas provide an opportunity to bring the outside world into children's minds.

Habitat dioramas, which had become unfashionable in the 20th century following their heyday in the United Kingdom during the 19th century, are currently attracting fresh interest as exemplified by recently opened dioramas in the Beginnings Gallery at the Museum of Scotland, Edinburgh and the new dioramas opened at the Natural History Museum in Malta in 2010. Unlike the dioramas referred to above, these very recent additions display African mammals and show the commitment of the present curator to such displays.

1.4 Malta's natural history dioramas

In outlining the educational rationale behind the dioramas, the curator stated that the settings were meant for visitors of all ages. One aim was to offer a showcase of what some typical Maltese habitats have to offer including an exemplar of the animals and plants that could be encountered in such habitats. Another aim was to offer an opportunity for free choice observation of unique museum exhibits representing flora and fauna in local habitats. These dioramas are constructed conceptual ones and not replications of actual identified places. According to curator John Borg, active observation of local flora and fauna is lacking in Maltese society, however I have not seen any evidence to support his claim. A third aim was to create conservational awareness and environmental responsibility. His intention was to present an example of a negative human effect on the local environment. This may be seen in the last diorama that includes a 'baked beans' can, which attracts the intended attention. The curator acknowledges that this tends to alienate visitors from appreciating the natural aspect to focus instead on the human effect on habitats.

Limited manpower and turnover of well-trained personnel is depriving the NHM of an educational structure. Heritage Malta's education unit and the curator were working to remedy this basic lacuna. The current idea is to have an activity room at the museum to serve as a learning zone. Well-trained staff appreciably knowledgeable on local ecology would be required. In the absence of such personnel, the curator occasionally served the role of museum educator. In the short term he planned to design worksheets purposely intended for the dioramas and that would enrich the educational experience of school children visiting the museum. These were personal initiatives not founded on any museum or educational research conducted at the NHM.

1.5 A case for natural history dioramas

Although they may not be the real thing, I still think that natural history dioramas have the potential to impart biological knowledge. Museum literature (Hein, 1998; Falk and Dierking, 2000) and educational literature does not afford much space to dioramas. Dioramas communicate messages from biology, ecology, environment and history through the medium of the exhibit. Dioramas of the natural world are a vital part of portraying the natural world to people, adults and children (Tunnicliffe, 2015). As snapshots in time, dioramas provide children with the chance to stand, observe, identify, raise questions and seek answers. 'Stand and stare' opportunities are not often possible at places with live specimens. So for cognitive learning, a natural history diorama in a museum is superior. A visitor, particularly a school child with a curricular focus, can recognize, identify and work out ecological relations between specimens as well as appreciate the flora and fauna of biomes. At dioramas, children develop the inquiry approach: they observe, ask questions, formulate hypothesis, which they try to validate by comparing scene in the diorama with their own experiences and previous knowledge (Tunnicliffe and Scheersoi, 2015). Scheersoi (2015) states that interest and learning can occur at dioramas if these evoke emotional responses. Visitors appreciate 'animal encounters' as provided by dioramas due to the possibility of close observation. Big, young or rare animals, animals in motion, interacting animals or artefacts in the diorama mostly capture visitor attention. In addition to promoting biological inquiry, dioramas provide ideal settings for the construction of biodiversity-related knowledge, especially at the levels of species and ecosystem diversity. This is because they originate from in a time when ecological relationships and communities were the prevailing natural science paradigm (Marantino et al., 2015). Other studies found that bonding to places depicted in habitat dioramas develops after visits to a specific place depicted or similar places and the overall familiarity with the places portrayed in the diorama (Garibay and Gyllenhaal, 2015).

Learning is embedded within social events and occurs as a person interacts with people, objects and events in the environment. Viewing a diorama is a social experience and varies depending on the culture from which the participant hails and the context and culture in which they are viewed (Tunnicliffe and Scheersoi, 2015). I see dioramas as telling a story to their visitors and story telling is a social act too. The role of the narrative in dioramas has been reported by several academics. Dioramas are very well suited to evoke dialogue and narrative about biodiversity. Cotumaccio (2015) found that by engaging audiences in narratives about the topics presented in dioramas, facilitators act as human interfaces between the exhibit's intended purposes and the visitor's interests. Facilitators can create scaffold between the visitor and the diorama content aiding the visitor to understand the content and connect it to their existing knowledge and interests. Stories about dioramas and their specimens provide visitors with more ways of making sense of the exhibits. This is a different type of museum experience that can be more effective than standing in front of a diorama looking and commenting (Dunmall, 2015). Marandino et al. (2015) observe that biodiversity dissemination and learning at dioramas deserves more research and agree with Tunnicliffe (1999) that dioramas are an underused educational resource. I tend to agree with this too.

1.6 Primary science and curriculum in Malta

Across Europe, there are mounting concerns about the type of science education provided to children and young people. In Malta, the system is riddled with the cumulative effects of several years of piecemeal strategies and decisions based on intuition rather than on empirical evidence. This history of piecemeal strategies has been the main obstacle restricting innovation in educational institutions and hindering the development of learner-centered pedagogies.

1.6.1 The state of primary school science

Local research (Borg and Falzon, 1990; Ventura, 1993) has identified a number issues and challenges that include the primary school teachers' lack of confidence in teaching science and lack of skill in using ICT to teach the subject and their inability to cater for the diversity of learners. Also highlighted is the need of high quality initial training and continuous professional development.

Research concludes that the current state of science teaching in primary schools is not effective. Apart from a lack of resources in schools, Maltese primary school teachers are reluctant, and in many cases refuse, to do science. They expect the science peripatetic teachers to do science lessons. The latter say that the class teachers are rarely present for their science lessons when they call at the respective schools. Consequently, follow up and continuity is lacking and some pupils have science only once a month (Chetcuti, 2009). Since the 2009-10 scholastic year changes have been implemented and primary classes in State schools have at least two science lessons a month by the science peripatetic teacher.

Malta did not fair well in the latest Trends in International Maths and Science Survey (TIMSS) of 2011. From fifty participating countries, Malta was placed 28th in Maths (Mullis et al., 2011) and 40th in Science (Martin et al., 2011). In Maths, nearly all other participating EU countries attained a better placing than Malta, while in science Malta trails all EU and developed countries. In both cases, Malta's result was significantly lower than the centerpoint of the TIMSS 4th grade scale.

The *Vision for Science Education in Malta* (2011) consultative document suggests that science curricula should a) provide opportunities for engaging with and exploring the natural environment; b) allow students to engage with science in a context relevant to everyday life experiences and c) provide opportunities for learning science in both formal and informal contexts. Inquiry-based Learning is advocated based on the 5E model i.e. Engage, Explore, Explain, Elaborate, and Evaluate. This model moves away from the traditional transmission model of teaching to a more interactive one where the students take on greater responsibility for their own learning. In the learning outcomes for primary education the document states:

> *At primary level, the main focus should be on children participating in meaningful science activities that allow the them to connect with the natural world around them and allow them to acquire a sense of their own competence in understanding and doing science. (pg.40)*

The Vision for Science Education in Malta makes no direct reference to local flora and fauna or to Biology in general. It basically proposes a culture change in the way science education is done in Malta, but it was not implemented since it was never made official policy. However, the new government has pledged to maintain the basic framework and consultations are underway on an implementation plan.

The executive summary of the NMC document outlines 14 general aims encompassing a wide range of educational topics (NMC, 1999). Aim 12 titled *Think scientifically and technically,* specifically states that after completion of compulsory education, a 16-year-old student should be able to demonstrate:

"understanding scientific language; classifying and describing; posing precise questions; ….using mathematical concepts; providing synthesis; using scientific apparata, etc."(NMC, 1999: 99).

The specific curricular aim at primary level is stated as:

"acquisition of the ability to forge a systematic link between core subjects such as Maltese, English and Maths with Science and Technology" (NMC,1999: 103).

The president of the Malta Union of Teachers (MUT), stated that 80% of the NMC remained unaccomplished (Vella, 2004) and together with it the science objectives. How much of the curriculum has been implemented would be difficult to determine and the Minister of Education was prompt in rebutting the claim (Stagno Navarra, 2004). However, the vast majority of teachers know that the MUT president is probably right. Excluding a few cosmetic changes, the status quo has been preserved practically in all the aspects of science education in Malta since the establishment of the NMC in 1999. The Co-ordinated Science idea was not well received by the majority of science teachers and has not yet been implemented. The NMC does not make reference to the value and need for out-of-school learning experience in science. Dr Paul Pace of the Faculty of Education is probably right in stating that:

"…..in order to attract more students to science, the way science is taught is more important than the content itself" (Debono, 2005).

The current provision of science schools in many countries is frequently considered to be boring, irrelevant, and outdated (Braund & Reiss, 2006: 1373). The Eurobarometer, found that two-thirds of young people (15 to 25 years) across the 27 EU Member States (Malta: 61%), agreed that natural science classes at school were not appealing enough (Gallup, 2008: 63). A negative or positive primary science experience tends to persist for the next six or seven years (Cerini et al., 2003: 18). The primary science rationale document refers to the nature of science in this way:

'Science is a means of discovering and understanding the world around us. It consists of a body of knowledge, which attempts to

explain phenomena and experiences. It also involves a number of skills and processes by which this knowledge is achieved and applied. Science is also concerned with the development of attitudes concerning scientific activity.' (Department for Quality and Standards in Education, 2005: 3)

The rationale focuses on the three main aspects of science: knowledge, skills and attitudes. Knowledge refers to the theories and concepts making up science. Skills refer to the method of posing questions and carrying out investigations in science. Attitudes are concerned with the way which scientific knowledge and its application is evaluated and appreciated together with an understanding of its limitations. The rationale also recognises the fact that there is no fixed way in which scientists work, but generally all investigations tend to have aspects of common processes such as observation, classification, hypothesising, data collection, interpretation of data and evaluation. The Primary Science Framework aims to support schools to meet these requirements. It aims to lay the foundation of knowledge and understanding, and to develop the skills and attitudes related to science through first hand experience. This foundation is intended to lead to a deeper progressive understanding of scientific activity, forming a basis for further study in science at secondary level.

1.6.2 Primary Science Curricula and Syllabi

The aims of the primary science curriculum are rather broad. Out-of-school science learning is not given its due importance, considering that pupils learn more science when out of class and their experiences are usually very enjoyable. Each year syllabus is divided into 3 main strands with the Biology related one called *Sharing Our World* that is divided into: a) Other Animals and Us, b) Plant life and c) Habitats. The following learning outcomes (LOs) are set:

1. Know that there is variety of living things.
2. Know that there are different kinds of plants.
3. Observe the many features that make the environment around us.
4. Know that there are different kinds of animals.
5. Know that a habitat is the environment in which a plant or an animal lives.
6. Observe that living things are suited to the habitat where they live.
7. Know that plants and animals in a habitat depend upon each other.
8. Group plants according to common features.
9. Observe differences between plants and animals.

Previously I have referred to the need for children to be exposed to nature and the need to be taught how to see, touch or note things. Current school curricula are not sufficiently providing exposure and learning opportunities for biology. Schools on a voluntary basis organise field trips to one of the nature reserves managed by BirdLife and Nature Trust (Malta). These two non-governmental organisations play a very important role in providing out-of-school opportunities to learn about local animals and plants.

1.7 Uniqueness of this research

Very little research has been carried out on the educational value and role of habitat dioramas. They do not feature in major museum studies texts such by Black (2005), Hein (1998), Falk and Dierking (2000), and Paris (2002). The few researchers who have studied habitat dioramas previously took various and different perspectives. Some have documented the historic, taxonomic and conservatory value of habitat dioramas (Insley, 2008; Morris, 2003; Quinn, 2006; Scheersoi and Tunnicliffe, 2009; Wonders, 1993). Others have looked at natural history dioramas as a unique genre of museum exhibit showing realistic representations of creatures that were alive and at what visitors learn from dioramas (Ash, 2004; Peart and Kool, 1988; Reiss and Tunnicliffe, 2007; Scheersoi, 2009; Stern, 2009; Tunnicliffe, 2005 & 2007). The educational potential and role in biological learning of dioramas has been, documented by various researchers (Ash, 2004; Insley 2007, 2008; Paddon, 2009; Peart & Kool, 1988; Piqueras et al., 2008; Reiss and Tunnicliffe, 2007; Scheersoi, 2009; Tunnicliffe, 2002, 2005 & 2007). One of few substantial studies on habitat dioramas is the doctoral thesis of Wonders (1993), which however deals mainly with the historic, technical, taxidermic and artistic aspects, rather than the educational role of dioramas.

This is the first thesis in Malta on habitat dioramas and their potential in biological and environmental learning. It is one of very few out of school undergraduate dissertations and master's theses, and certainly the only PhD to date. Very little work on biological and environmental learning at primary school level has been carried out in Malta and most studies are at secondary (middle school) level. The curator at the Natural History Museum, Malta confirmed that neither any research on the display area nor any formal assessment of the diorama's effectiveness had ever been done before this doctoral research (Borg, 2010). The research in this thesis is unique in the field, not least since it was conducted in a micro-island state with its own cultural context and long colonial history. The pupils had never previously visited the Natural History Museum in Malta and there is no formal program for museum visits. A visit depends on the initiative of both teacher and the school or the ethos of the school. The technique for analysing the drawings and interpreting the habitat dioramas using the software package Atlas.ti has not been previously, to my knowledge, encountered in literature. This present research explores: a) the potential of habitat dioramas as biological models for visualization of local flora and fauna (Reiss and Tunnicliffe, 1999), b) the expression of the mental models through drawing (Cox, 1992: 88-91; Rapp and Kurby, 2008; Reiss & Tunnicliffe, 1999: 142) and c) the potential of habitat dioramas for learning in Biology. Another unique feature of this thesis is the theoretical model I present in section 6.5 (pg.224).

1.8 Rationale for the research

Research on learning and teaching outside the traditional classroom environment, especially in museums, has grown tremendously in the past 15 years. Despite the exponential growth in the field of informal or free choice learning, there is still need for further research to better understand how people interact, participate and learn in such settings. Studies of learning in informal settings have mostly avoided complex learning theory and are rather based on a learning-by-doing perspective weakly relying on general constructivism (Ash & Rahm, 2012: 2). Recent research is increasingly focusing on the social context of learning in out-of-school settings (Anderson, 2012: 17).

Malta with its sparse endemic flora and fauna and over a third of its surface area occupied by building, offers limited opportunities for engaging with nature. The current primary school curriculum is not addressing this issue in a substantial manner. The dioramas can in part remedy the inadequacy of the primary science curriculum in providing experiences with nature. The habitat dioramas at the NHM offer another opportunity to children to observe local flora and fauna and become familiar with the biology of their country's biota.

They are presently an underutilised educational resource. Dioramas become particularly valuable to the urban community in constructing understanding of the different habitats and interactions between organisms (Tunnicliffe, 2005: 24).

Philosopher and educationist Johann Comenius (1592-1670) held that education should be universal, optimistic, practical, innovative, and focus on family and social life. His beliefs, including the promotion of an 'authentic curriculum', have influenced educational thought for practically four centuries. Comenius believed in the direct contact with biological objects for learning about nature. He suggests a school garden as a perfect place where concrete learning could occur. A garden offers the opportunity to children to leisurely gaze upon trees, flowers and herbs (Rowe and Humphries, 2004: 19). Habitat dioramas also offer opportunities for contact with natural forms that are not always readily accessible or easily visible.

Contemporary educationalists often overemphasize the importance of formal school-based learning and do not sufficiently recognize the contribution that informal contexts can make (Braund and Reiss, 2004: 3). I, like other researchers, (Braund & Reiss, 2006; Eshach, 2007; Falk, Storksdieck & Dierking, 2007) hold that we should aim to harmonize in-school and out-of-school learning practices. I also feel that the primary curriculum in Malta does not give sufficient importance to out-of-school learning.

About two-thirds of the time school age children are awake is spent outside formal schooling (Braund & Reiss, 2006: 1375; Eshach, 2007: 171). Based on my experience, I believe that educators tend to overlook, the crucial influences that out-of-school experiences have on pupils' knowledge and understandings, and on their beliefs, attitudes, and motivation to learn. A well-planned field trip can achieve more than a conventional school science lesson could ever do. A survey of pupil's views on improvements to their science curriculum revealed that trips and fieldwork were their top priority for better school science (Braund and Reiss, 2004: 11). In the Student Review of the Science Curriculum: Major Findings (United Kingdom) it was reported that from the 11 possibilities, 'going on a science trip or excursion' was rated as the most enjoyable, although not the most useful and effective, manner of learning (Cerini, Murray and Reiss, 2003: 10). The 2005 study, *What did you learn at the museum today?* (MLA, 2005) found that pupils were very enthusiastic about their museum experiences and confident about their own learning. Most of the pupils (26,791: KS2 and KS3) in the study enjoyed the day's visit, learnt some interesting things, thought museums were good places to learn in a different way to school, said the visit had given them a better understanding of the subject and said the museum visit made school work more inspiring. Pupils and teachers also cherished the emotional engagement that museums allow which is important in stimulating the attainment of knowledge and understanding as well as the development of attitudes and values (Hooper-Greenhill et al., 2005: 15-16).

1.8.1 Research Objectives

This research investigates the visual impact of habitat dioramas on children; how they visualize the exhibit to build a mental model; how they make sense of the dioramas to understand local flora and fauna; how previous knowledge influences the way children visualise habitat dioramas; the role of habitat dioramas in our time of renewed interest in conservation and biodiversity.

The following are the basic aims of the research:

1. To reveal the mental models (internal representation) of local animals and plants that school children hold and how these are expressed in drawing?
2. To find out what in the dioramas captures the children's attention, which species of animal and plant children see mostly and how far this is influenced by knowledge held.
3. To tract any development as a pupil progresses through drawing tasks?
4. To assess the potential of dioramas as models in biological learning and for gaining of representational insight?

The main research question for this research is the following:

> ***How do Maltese children visualise animals and plants in natural history dioramas through the lens of their previous knowledge?***

Subsidiary questions:

1. What mental models (internal representation) of local animals and plants do school children hold and how are these expressed in drawing?
2. How far is the mental model modified by the novelty of the museum?
3. Which dioramas are preferred, what captures the children's attention and what role does culture play in this? Which species of animal and plant do children see most?
4. Which changes occur as a pupil progresses through drawing tasks?
5. Are dioramas appropriate as models in biological learning and for gaining of representational insight?

Approaching the question requires a long process of thought and consideration. The research was carried out with 9-year-old boys and girls from a mixed ability Maltese state school. The research was partly conducted in class and partly at the National Museum of Natural History in Malta. I used drawings to probe what the children already know about local animals and plants that they encounter in their everyday lives, and how they visualise the diorama.

The next chapter is a literature review of empirical studies related to children's understanding of biology, flora, fauna and studies pertaining to museum learning and biological learning from dioramas.

2 Biology and Dioramas

"An ever-growing body of evidence demonstrates that most science is learned outside of school."

John H. Falk and Lynn D. Dierking.
American Scientist.

The chapter starts with presenting the different ideas about the term 'nature' and its significance to children. Next I compare the direct experience of natural settings to that afforded by dioramas, followed by a discussion on how children interpret animals and plants. The rest is a discussion of museum objects, natural history dioramas and learning that occurs there.

This research's main objective is to investigate how Maltese children see animals and plants in habitat dioramas and how this is influenced by their previous knowledge on flora and fauna. We thus need to look into the expression of the children's mental models and the influence of the museum settings and objects on such models.

2.1 Nature and children

Defining the word 'nature' is complex and problematic (Mergen, 2003). The major dictionaries define 'nature' as the physical world in its primitive untouched state collectively, including plants, animals, the weather, the sea, mountains and other features and products of the earth, as distinct from and uncontrolled by human beings (Oxford, Cambridge, Chambers, Collins, Longman). In contrast Richard Louv, without including everything, gave a definition of 'nature' in general to mean natural wilderness with all its biodiversity, including humans (Louv, 2008: 8-9). The term 'mother nature' brings to mind 'Gaia', the name given to Earth by the ancient Greeks, as the mother who confers life and receives the dead into her rich soil. Historically, nature has been viewed by some as forbidden wilderness. Those who considered nature as powerful and dangerous wilderness thought of it as a phenomenon to be tamed (Moran, 2006: 59).

There is also variation in what "nature" is perceived to stand for. There is an assumption that humans generally prefer savannah-like landscapes since current paleontological evidence supports the origins of humans in East African grasslands (Mergen, 2003). Another perception of "nature" is wilderness, the term covering a wide range of environments in pristine state, while in fact they are already scarred by generations of misuse. Meinig (1979) argues that even though different people may look in the same direction at the same time they cannot see the same landscape. There are at least ten different ways of seeing a 'landscape'.

In Biophilia , EO Wilson (1984) suggests that humans have an innate desire to know and be with nature and all that it sustains (Cramer, 2008). In his best seller, *Last Child in the Woods,* Richard Louv (2008) calls the lack of nature in the lives of today's 'wired' or 'backseat' generation (Karsten, 2005) as 'nature-deficit' and links it to some of the modern negative childhood trends, such as the rises in obesity, attention disorders, and depression. An emerging body of scientific evidence indicates that direct exposure to nature is essential for physical and emotional health (Louv, 2008: 35). Play within the realm of nature appears to be important for developing the capacities for creativity, problem-solving, and emotional and intellectual development (Gomes, 2013; Hordyk et al, 2014; Kellert, 2005; Wilson, 1994). If a person experiences inclusion with nature, he or she should care about nature and be committed to protecting it. However, if an individual experiences exclusion from nature, that person will protect himself or herself over nature (Schultz, 2002). Moreover, family values toward nature are a strong factor that can influence children's connection to nature. In circumstances where we cannot change children's near-home environment, non-formal educators could provide more opportunities such as environmental education or outdoor education programs for children and their families to learn about and experience nature (Cheng and Monroe, 2012).

2.1.1 Direct vs indirect natural experience

Kellert (2002) raises an interesting point about the importance of direct experience with nature versus indirect, mediated and vicarious experience. He argues that, compared to a constructed human environment, the natural environment changes rapidly, attracting a child's attention and stimulating it more. Children of different ages value nature in different ways: ages 3-6 years exhibit utilitarian and negative attitudes; 6-12 years develop aesthetic, humanistic and symbolic values of beauty appreciation, emotional bonding and imagination, while adolescents manifest ethical and spiritual relations to nature (Lee, 2012).

Nature is full of sights, sounds, textures, and experiences. The natural world and the experiences imbedded in nature are readily available to provide hands-on opportunities that promote growth and development in all of these areas. Teachers need to provide children with opportunities to experience the elements of nature that surround them and raise children's comfort level and awareness of the natural world. Children can begin exploring the backyard and the school playground, before they embark on a field trip to the woods or a park. Regardless of how basic a trip may appear to be, interacting with nature opens up a whole new world for many children (Kupetz and Twiest, 2000).

In nature all five senses are invoked, while at a museum it is mainly sight, and possibly auditory and/or odour. This is the main shortcoming of natural history dioramas, being static representations even if they offer depth and perspective and occasionally sounds and smells. They show natural settings, but they cannot replace the actual habitat and offer the same experience. What they can offer is a unique and quite particular experience, as I will show later in the thesis.

2.2 Children interpreting animals and plants

Young children do not apprehend that all animals perform basic physiological functions such as eating, breathing and reproducing. However, 10-year-olds seem to resemble adults in many aspects even in seeing humans as one type of mammal among various others.

> *"If I am correct in my analysis, the restructuring of the child's knowledge of living things in the years before age 10 crucially involves changes in causal explanation. The 4 to 7-year-old interprets what for adults are biological phenomena in terms of psychological causal notions. By age 10 the child has constructed a system of biological explanation as well" (Carey, 1985: 194).*

In a six-year (2000 to 2005) longitudinal study of 5-11 year-olds' understanding of what is inside themselves, Tunnicliffe and Reiss (2006) found a progression in knowledge. All children demonstrated an increase in biological knowledge as they aged. Knowledge development progressed from just an awareness of an organ to an understanding that an organ relates to other organs.

Piaget (1929) held that naming in children develops in stages with age. From the stage where the name of the object is part of it to the stage symbolised by the discovery that names come from within us and children affirm that they are “in the head” at age 9-10 (Piaget, 1929: 81-85). When people look at biological exhibits in a science museum, a botanic garden or a zoo they construct meaning from what they observe whatever it may be, an animal, a plant or a constructed artefact, and they label it (Bruner et al. 1956). Young children’s thinking is in terms of general prototypes within a category. They think of all dogs simply as ‘dogs’ without distinguishing within the class and rarely are they viewed as animals (Gardner, 1980: 65-66).

When children encounter animals and plants in places such as parks, gardens, school fields, streets or squares, their home or zoos, farms, nature reserves and natural history museums, they interpret and try to make sense of what they see. Tunnicliffe (2002) found that primary school and family visitors to zoos and museums have a need to identify specimens using non-taxonomic basic terms. They usually hold a basic concept of the animal, which leads them to make remarks on size and anatomy. They also comment on behavioural aspects such as; position in the exhibit, locomotion, feeding and other activities that attract observer attention such as parental care (Tunnicliffe, 2002: 39). Tunnicliffe and Reiss (1999) investigated how children aged 5 to 14 years recognize, identify and group animals. The majority of children gave anatomical rather than behavioural or habitat reasons for naming and explaining animals. In other studies with 7-12 year old children, it was found that when making animal focused comments, they mentioned names, but also behaviour and body part comments featured prominently (Tunnicliffe and Osborne, 1995: 18; Tunnicliffe, 1996: 136). At dioramas, young visitors:

1. locate things spontaneously or assisted by signage;
2. identify and describe them spontaneously from own experience, knowledge and observation;

3. interpret through story telling from own knowledge or using museum information and messages (Tunnicliffe, 2005: 29).

Bell (1981) investigated the concept of animal with 10 to 15 year olds. She found that the term 'animal' appeared to be restricted to the four-legged, large and terrestrial mammal category. Practically all pupils classified the cow, cat, lion and elephant as animals. In contrast, only half categorized fish, frog, snail, snake or whale as animals and very few classified a spider, worm or butterfly as such (Bell, 1981: 55-56). The results of a study in Malta with 4-5 year olds are in line with Bell's findings. The vast majority of Maltese children categorized the cat, dog, elephant, horse, mouse, pig, sheep and zebra as animals, but just over half did so for the dolphin, ladybird and spider. The children used appearance such as four legs, tail and fur, noise production, size and habitat to decide whether the organism was an animal or not. Huxham et al. (2006) found in the UK greater knowledge about mammals than about birds and arthropods. Interestingly, apart from the selected animals, most Maltese children also mentioned a variety of non-endemic species such as tiger, lion, crocodile, giraffe, shark and leopard (Tunnicliffe et al., 2008: 217-218). These results suggest that young Maltese children's knowledge of local fauna is limited. Local habitat dioramas may serve to enhance awareness and interest toward local flora and fauna.

American children were more interested in endemic animals compared to national or international animals (Patrick and Tunnicliffe, 2011: 639; Trowbridge and Mintzes, 1985, 1988). In a study conducted in Brazilian schools, Bartoszeck (2009) found that 6-8 year olds mainly mentioned earthworm, bird, butterfly, toad and pigeon as animals they see around them. As pets they mentioned dog, cat and fish, and hen, duck, goat and horse as farm animals. When probed on knowledge about insects, Brazilian 4-6 year olds could spontaneously recall very few names among which were butterfly, bee, beetle, ant and surprisingly caterpillar (Bartoszeck et al., 2009: ESERA conference proceedings). The results of these studies show that children from different countries vary in what they consider as an 'animal' when compared to Maltese children and this could be due to cultural variances of the respective countries.

Gatt et al. (2007) investigated 4-5 year old children's knowledge and exposure to plants, and the conceptual framework used to classify a specimen as a plant. When asked to mention plants, a third of the pupils in the study did not give a single name and very few were able to mention more than three examples. Children most frequently gave the super-ordinate categories 'flower', 'tree' or 'plant' and a few mentioned 'rose' and 'sunflower'. Most commonly mentioned trees were the orange and the apple followed by lemon. For many pupils one characteristic sufficed to classify the specimen as a plant. Specimens that fitted in the mental model were classified as plants; the example of lettuce fitted because it was green in colour, but cactus did not since it has spines in place of leaves. The focus is on parts rather than the whole of the plant. Some could not distinguish between names of plant parts and the plant itself.

2.3 Museum Learning

> *"At the level of individuals within the real world, learning does functionally differ depending upon the conditions under which it occurs. Hence, learning in museums is different from learning in any other setting by virtue the unique nature of the museum context" (Falk, 2000: 136).*

Museums have a long history and educational legacy with science learning. Ptolemy I is presumed to have built the first museum in Alexandria as early as 290BC, used as a center for learning dedicated to the daughters of Zeus who presided over the arts and sciences. Established in the late seventeenth century, the Ashmolean was the first recognizable museum with its own dedicated building that functioned as a center of academic scientific activity within the University of Oxford. At present, the museum sector in the United Kingdom comprises a large network of providers of science education spanning large entities such as the Natural History Museum (NHM) and Science Education in London to their regional satellite museums of scientific or technological nature (Braund, 2004: 113).

In the United States, the emergence of the museum movement and the development of the natural history museum model followed the trends of the European museums of the time. In their early beginnings, European natural history museums were private collections of interesting natural artefacts gathered and identified by members of the elite class. The majority of these early museum collections were in fact the property of royalty and were exclusively accessible to individuals belonging to a very privileged class. Later, museum accessibility was widened and some museums even became public institutions as a result of increasing democracy (Melber and Abraham, 2002: 45).

In 1939, the American Association of Museums (AAM) acknowledged the increased attention dedicated to the educational role of museums, endorsing the raison d'être for museum education. In its publication *The Museum in America,* interestingly one notes that 'more extensive work with children' was clearly advocated. Developments that occurred in the 1960s and 1980s saw education came once again to the forefront of museums as a larger goal. As a time of great social change, the experimentation in formal educational methods was often reflected in the informal setting of museums (Melber and Abraham, 2002: 47). A period starting from the 1970s saw a constant expansion of science museums, children's museums, aquariums and similar experiential centres together with a conscious shift from a curatorial (object-based interest) to an educational (audience-based interest) focus. Changes that reflect this shift occurred in the NHM in London in the early 1970s, the Field Museum of natural history in Chicago in the late 1980's, Milwaukee Public museum in the 1950s to 1960s, Boston Children's museum in the 1960's to 1970's and the Exploratorium in the 1970s to 1980s (Bitgood et al., 1994: 66).

The following are some aspects of what the learner does in an informal setting that are specifically appropriate to museums:

1. Making quick associations between what is already known and new knowledge, which may yield new relationships.
2. Experiencing the authentic through seeing the real thing or experiencing the actual phenomena or having access to accurate simulations.
3. Having experiences involving naming, identification, observation, imagination, fantasy, imitation, role-play, cooperation, demonstration and discovery.
4. Having no limitations, tests and lectures.

Unlike schools, museums tend not to exercise power over their visitors in their engagement with an exhibition (Kress, 2010: 39). Although every individual's museum experience is unique, there are shared human reactions and response patterns, such as attention, memory, reasoning, feeling and motor skills, that may be systematically studied and described (Bitgood et al., 1994: 63-64).

The learning experience offered by the museum must consider the type of audience i.e. families, young children, teenagers, beginning or experienced learners and people who learn through looking, reading or doing. In the case of school children, one needs to cater for varying abilities and behavioural characteristics of different individuals in class (Hooper-Greenhill, 1999: 141-2).

As consensus formed on the importance of the natural history museum as an educational facility, so grew the demand for academic research studies exploring various issues of pedagogy and learning theory in the museum environment. The National Science Teachers Association recognized the contribution museums make to the education of school-aged children as well as adult learners and publicly supported the educational efforts of museums and other informal education facilities.

Natural history museums have a dual role. Firstly, they serve as sites for research and scholarship involving the museum themes focused on the collections and those who preserve and study them. Secondly, they offer the public programs, which promote the outer museum and the educational mission of the institution. In other words, not only are wildlife collections invaluable for research purposes, but they play a central part in the education of the visiting public. Little can rival direct interaction with authentic specimens – for the scientist and the general visitor alike. On mentioning wildlife open spaces occupied by large predatory animals, such as an African Savannah, come to mind and therefore museums as stores of artefacts could be considered as the antithesis of authentic wildlife. On the other hand, through their exhibits they offer visitors opportunities to see specimens from wildlife that would otherwise be difficult to encounter.

Dioramas are unlike other models in science in that they depict what is already recognised as plants or animals rather than rendering visible what cannot be seen such as atomic structure and molecules or seek to physically embody abstract ideas or complex theories. Traditionally, dioramas present life-sized organisms as found in nature in exhibits that are for looking at only.

Quinn (2006) advocates the authenticity of habitat dioramas at the AMNH and states that visitors most frequently respond to the dioramas by asking “Is it real?” People visit and stop to look at natural history dioramas convinced they are observing ‘the real thing’ (Quinn, 2006: 8). Do habitat dioramas depict reality? Natural history dioramas can be quite realistic if they are designed on an actual habitat and skilfully constructed by capable taxidermists. Dioramas could be said to be romanticising nature because some idealisation is likely to have taken place in the re-situation of the real world into an artificial setting. For Reiss and Tunnicliffe (2007) ‘Dioramas are like soap operas’ in that they show rare instances occurring on a daily basis. Their distinctive stillness augments a rather unrealistic character. They have a ‘Garden of Eden’ feel where animals are ‘inevitably shown in the prime of health and physical fitness’ with no sign of disease or malnutrition (Reiss and Tunnicliffe, 2007: 3-4). Animals can be grouped together in less space and show various forms of animal behaviour simultaneously that, even in the species-rich Serengeti, would be almost impossible to encounter or for a photographer to capture on film. ‘Creating a realistic diorama is exceedingly difficult’ (Morris, 2009: 28). Quinn (2006) unequivocally believes that the effect of habitat dioramas ‘is so convincing’, but Morris (2009) holds that ‘convincing dioramas are extremely difficult to create’.

Visit of collections of animals at zoos, farms and natural history museums are part of the primary school tradition. Tunnicliffe (1999) categorises sites for science out of school according to their focus on naturally occurring things-organisms and artefacts. The naturally occurring exhibits are divided into living things and geological specimens, with the former being alive, dead or three-dimensional representations such as robotic models. Natural history museums being repositories of past and present specimens, present dead, inanimate organisms. Studies (Tunnicliffe, 1996) show that comments made at zoos on live animals did not vary much from those made at museums on static, preserved animals. When presented with stuffed animals, pupils use mainly anatomical cues, rather than behavioural or habitat related cues (Reiss and Tunnicliffe, 1999: 146).

The dioramas present an ecological setting, local or foreign, through which children may appreciate the natural richness of various habitats. Wildlife dioramas bring children closer to nature, which most may only experience in books, television, internet and other multimedia portals. I am interested in knowing what the pupils point out and say to each other, what grabs their attention and how they interpret the exhibits. The knowledge about wildlife that the children already hold is an important aspect to take into account. In this research, prior knowledge will be probed by class, museum drawing and the construction of webs as explained in the methodology chapter. Ausubel's idea that 'the single most important single factor influencing learning is what the learner already knows' (Bell 1993: 6), applies in informal settings as much as it does in schools (Tunnicliffe et al., 1997). Benefits of learning at museum exhibits may be maximised when the required level of pre-visit knowledge and understanding is established.

2.3.1 Interest, objects and learning

Interest allows for correct and complete recognition of an object, leads to meaningful learning, promotes long-term storage of knowledge, and provides motivation for further learning. Dewey holds that apart from effort, interest is required for meaningful learning to occur without the need for coercion. Interest-based learning is characterised by a sense of pleasure arising from the activity and from satisfying one's psychological needs (Schiefele, 1992: 151).

The creation of interest needs a situation-specific interaction between person and the object. There are two types of interest (Schiefele, 1991: 302):

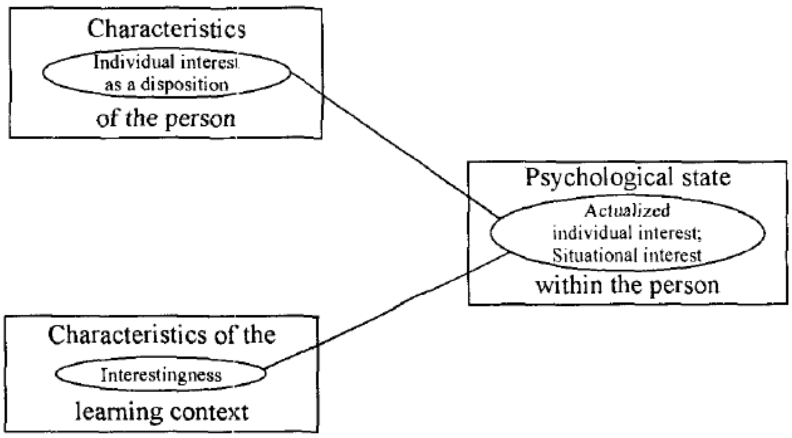
Situational: emerges in response to situational cues.

Individual: a deeper interest that develops over time and resides with the person.

Individual is conceived of as relatively enduring preference for certain topics, subject areas or activities. Situational: is an emotional state brought about by situational stimuli. A person in a state of being interested in a certain topic wants to learn about that topic for its own sake. Findings suggest that subject matter interest has a stronger and more consistent impact on the quality of experience in class than do achievement, motivation or ability (Schiefele, 1991: 314).

Krapp, Hidi, and Renninger (1992) have identified three conceptualizations of interest which play an important role in contemporary discussions on motivation and interest: (1) interest as a dispositional characteristic of the person, (2) interest as a characteristic of the learning environment (interestingness), and (3) interest as a psychological state (Krapp, 1999: 24).

Figure 2-1.Psychological State Determinants (Krapp, 1999)



Adapted from Krapp, 1999.

This idea is variously referred to as "person-object-relationship". It is important to realize that research on individual interest is mainly concerned with the subjective side of the "person-object-relationship" (Krapp, 1999: 25). A person will only engage continuously in a certain topic area or object of interest if he or she assesses it as sufficiently important and if he or she experiences the course of interactions on the whole as positive and emotionally satisfactory.

In Self-Determination Theory (SDT), Deci and Ryan (1985) distinguish between intrinsic and extrinsic motivation. Intrinsically motivated behaviors, which are performed out of interest and satisfy the innate psychological needs for competence and autonomy, are the prototype of self-determined behavior. Extrinsically motivated behaviours can vary in the extent to which they represent self-determination.

Their approach centers primarily on psychological needs namely, the innate needs for competence, autonomy, and relatedness which are the basis for one maintaining intrinsic motivation and becoming more self-determined with respect to extrinsic motivation (Ryan and Deci, 2000: 65). However, they naturally recognize that basic need satisfaction ensues in part from engaging in interesting activities. They at times speak of intrinsically interesting activities, but when they do so they are really only talking about tasks that, on average, many people find to be intrinsically interesting (Ryan and Deci, 2000: 56). If students are free to return to the activity, it is assumed that, if there is no extrinsic reason to do the task (no reward or no approval), then the more time they spend with the target task, the more intrinsically motivated they are for it.
Since most of the tasks that educators want their students to perform are generally not inherently interesting or enjoyable, knowing how to promote more active and volitional (versus passive and controlling) forms of extrinsic motivation becomes an essential strategy for successful teaching. Choice and the opportunity for self-direction appear to enhance intrinsic motivation, as they afford a greater sense of autonomy. Several studies have shown that autonomy-supportive (in contrast to controlling) teachers catalyze in their students greater intrinsic motivation, curiosity, and the desire for challenge (ibid).

Learning, in the sense of building ('constructing') knowledge and understanding, is a combination of cognition, motivation and interests. Not only motivation, but also interests have a great impact in the teaching (and the learning) process. On the person-object theory of interest (POI), Krapp (2007) states: "The empirical findings show that learning motivation based on interest tend to have many positive effects on the process and the results of learning" (cited in Klingenberg, 2009: 2). Objects of interest can be a concrete thing, a topic, a subject-matter or even an abstract idea. The POI theory approach is based on "person-object-relation" characterized by feeling and value-related aspects (Krapp, 1999: 24).

At natural history dioramas children stop, look and interpret what they see, their attention captured by particular features. Such situational interest is central to learning, particularly in non-formal learning environments where visitors may be regarded as free learners (Scheersoi, 2009: 10). Dioramas stimulate situational interest if they evoke emotional responses and provide different anchor points, which enable visitors with varying individual backgrounds to relate previous experiences to artefacts observed. Person-object-engagements with diorama may produce feelings of enjoyment, involvement and stimulation that are typical emotional aspects of interest-based activity. Situational interest arises from: recognition of familiar, young or big animals and the unexpected (Scheersoi, 2009: 12).

The use of animals in biological education has been a field of discussions since Comenius' theorem "Lessons should begin with consideration of the real thing, instead of descriptions with words, after the thing has been shown, the teaching should follow to explain it" (Klingenberg, 2009: 6). Scientific instruction cannot replace everyday-experience with animals, which is a significant positive influence in building up elaborated concepts of animals. This means, that curricula and especially biological education should cover at least some of the issues regarding the fauna. It should be emphasized here, that supporting knowledge acquiring and attitude changing (towards a positive mentality), is more effective with animals than with other methods. The famous pedagogical reformer and school founder Christian Gotthilf Salzmann (1744-1811) integrated animals in his teaching on every opportunity and stated "As a result of my long time experience, nothing catches children's attention as early (and as much) as animals" (Klingenberg, 2009: 9).

2.3.2 Museum objects and interpretation

Expressed in the language of things, the theory affirms that object is to interpreter as text is to the reader. As texts without readers are empty, so museum objects are bare receptacles without the agency of museum visitors. Meaning is not "put into" a text or object to be "taken away" by someone who "finds" it there, but comes into being through inter-subjective participatory experiences. All participants bring certain dispositions to the encounter and no one of them has a greater claim than others to possession of the "true" meaning of the object (Hein, 2000: 63-64).

Unlike texts, understanding objects is more complex since the categories of meaning are more ambiguous with objects than with texts and meaning is not articulated in words (Hooper-Greenhill, 2000: 114). Hooper-Greenhill (2000) states:

> *Objects can also be read, spoken, and written about, encountered through verbal knowledge. Understanding is a process by which people match what they see and hear with pre-stored groupings of actions that they have already experienced (pg. 116).*

Meaning is dialogic – a dialogue between viewer and object. Body and mind confront objects equally, consolidating the relationship between the senses and cognitive processes. Understanding is a process by which people match what they see and hear with pre-stored groupings of actions that they have experienced. Each person has a unique mental map of knowledge depending on prior cultural and biographical experiences, meaning that each person will process new information in ways that are specific to him or her as individuals.

Museums are distinct as educational institutions chiefly due of the central place they have assigned to objects as sources of education. Museums put people immediately in the presence of things, to learn from or through them. (Hein, 2000: 108). Museums are truly educational when they aid visitors to apply what can be experienced in the museum to the world outside. Visitors bring their personal history to experience, but that too is framed within culture that teaches its members how to experience and understand objects informally. To learn from museums, one must become acculturated to them and to "museum literacy," that includes the ability to "read objects" (ibid, pg.110). One of the unique characteristics of museums and zoos is the presence of objects or animals. Wakeman (1986) found that live animals were no more effective than "dried" or video presentations in teaching most concepts. When museum objects or zoo animals are used, a simple repetition of classroom experiences is avoided (cited in Bitgood, 1989: 3-6).

2.3.3 Learning from Museum Objects

The U.S. General Management Plan Dynamic source book (2008) provides the following definition of a museum object:

> *A museum object is defined as a material thing possessing functional, aesthetic, cultural, symbolic, and/or scientific value, usually movable by nature or design. Museum objects include prehistoric and historic objects, artefacts, works of art, archival*

material, and natural history specimens that are part of a museum collection (GMP Source book: 2008).

To Hooper-Greenhill (2000) objects do not exist outside interpretations of their meaning and significance. Their interpretation is rooted in existing experience and knowledge, while always being targets for feelings and actions. According to Hein (2000) materiality is not essential to 'objecthood' nor is perception a sufficient condition of objective existence. All objects are artefacts, a fusion between encounter and interest, irrespective of being natural or man made. On the other hand, to Hooper-Greenhill (2000) only man made things are artefacts, while the term 'specimen' is an object that belongs to the natural world (p.106). Therefore in the classical sense a diorama, as a museum object, is an artefact, but which contains animal and plant specimens in an ecological relationship. Tunnicliffe (2013) asks whether diorama animals and plants should be considered as museum cultural objects or should they be considered as a sub-genre of objects. Object with particular characteristics as static entities that are observed not by handling. Visitors can view them and look with meaning at the organisms in the ecological, geological and meteorological context in which they lived.

Commonly authentic is used to describe objects, such as dinosaur fossils, that originate in nature. "Artefactual" objects, such as original works of art, arise from intentional human activity. I agree that a specimen obtained from its habitat is authentic, but any human construction is an artefact and so not naturally authentic form a biological point of view. A new modern paradigm holds that an object's authenticity is less essential to learning when compared with its potential to support visitor participation (Eberbach and Crowley, 2005: 318). Curators of Smithsonian Institution, Spencer Crews and James Sims, declared that authenticity is located not in objects, but in the historical concepts they represent (Hein, 2000: 62).

H.S. Hein (2000) holds that:

In the transition from object to museum object, things gain and lose dimensions of use and exchange value as well as other dimensions of meaning. What was one of many becomes unique; what was *functional becomes idle; what was private becomes public. Yet the present condition incorporates the prior state and depends on it for its own meaning (pg.55).*

Museums play an important part in validating object status. Museum objects have prima facie value independently of the material properties they possess and status in an earlier place. The physicality of museum objects is secondary to their function as signs or symbols (Hein, 2000: 55). Children seek access to genuine artefacts and give importance to being able to see, touch, and otherwise sense artefacts and objects (Dockett et al., 2011: 23).

2.4 Natural history dioramas

Experiences with animals and plants have become ever more important in the light of the mantra 'children out of touch with the wildlife'. One can hardly refute the impression of a diminishing knowledge about the living world both on an individual and cultural level. Globally mobile, technological societies have experienced a noticeable deterioration in understanding of the living world. There is at times such paucity in contact with organisms that having a goldfish as a pet can produce significant differences in children's biological reasoning. Moreover, people's contact with nature may greatly decrease when they move from rural to urban settings (Medin and Atran, 2008: 36-37).

Curatorial opinions of natural history dioramas revealed the important role this form of display can play in contemporary museums allowing for multiple interpretations on numerous levels. Curators acknowledge the ability of dioramas to reach a wider audience and increase access; 'It's actually a great form of non-literary communication…dioramas have such a major role to play in communicating without words' (Paddon, 2009: 26). Dioramas could well be an old museum technique, but they continue to awe visitors. Exhibit animals, like those in farms or in the wild, have an apparent fascination for human beings (Scheersoi, 2009; Tunnicliffe and Scheersoi, 2010). Dioramas, however, remain very popular attractions and are main attractions in the American Museum of Natural History (AMNH) in New York and Canadian Museum of Nature in Ottawa (Insley, 2007:33). Steve Quinn, (AMNH) believes that the popularity of natural history dioramas is secured and states:

I believe the reason they are so popular is that they evoke the same emotional response to viewing wildlife in nature. It's the same epiphany that occurs when one experiences beauty and wonder in the natural world (Insley, 2007:35).

Awed at their scientific fidelity and the subtle mastery of their painted backdrops and expressive taxidermy, the new generation of museum professionals is snubbing the notion that the diorama is an old-fashioned 19th-century anachronism. Habitat dioramas today have a unique conservational significance. Naturalists now accept that dioramas are venerable exhibits that represent pristine habitats at present suffering from overdevelopment and environmental pollution. An increasing number of the mounted creatures sealed behind the glass are now extinct and others are on the global list of endangered species. Examples are some avian species found in the passenger pigeon display in the Birds of New York State exhibition of the American Museum of Natural History. The museum's president, Ellen V. Futter, described dioramas as the earliest forays into virtual reality and valuable windows on lost ecosystems, authentic snapshots that show, in dramatic terms, the quality of our loss (Collins, 2003).

Discovering when the first diorama appeared in a museum is by no means simple, and there exists no set definition of what a diorama is. The term diorama is derived from the Greek "dia" (through) and "horama" (what is seen). In 1822, the Frenchman Louis Daguerre creator of the Daguerreotype fame patented the diorama, however this was a theatrical device with a mechanically revolving platform. Later, the term was adapted by museum displays, to describe realistic three-dimensional representations of life in natural settings. It is believed that the American painter and naturalist Charles Wilson Peale created the first museum diorama in 1784. Peale's museum in Philadelphia was a family establishment that showed the natural history of America and portraits of important men of the day (Insley, 2007:34).

According to Karen Wonders the venerable natural history diorama originated in the 19th century (Wonders, 1993). The habitat exhibits and dioramas probably originated in 1809 at Piccadilly in London. There the amateur naturalist William Bullock inaugurated his collection of taxidermic exhibits that included artificial plants and painted backgrounds that rapidly became a popular place of enjoyment and attracted more than 80,000 people in its first few months (Coe, 1986:3). In 1784, Charles Wilson Peale opened his celebrated collection in the United States in Philadelphia and remained for 70 years. To Peale, who was a painter, it was natural to conceive of the idea of displaying birds in their natural habitat presented against painted landscapes in his glass-fronted cases. Peale was dedicated to public education and wanted to render his exhibits attractive and systematically arranged. A hundred years later, the British Museum developed the technique of presenting mounted birds in life-like poses surrounded by artificial props to simulate their natural habitat (Wonders, 1993).

Known as the 'father' of modern taxidermy, Carl Akeley began the tradition of innovative exhibits dubbed "The Milwaukee Style" after starting his career at the Public Museum in Milwaukee, Wisconsin. Completed in 1890, Akeley's muskrat colony is considered to be the museum world's first total habitat diorama, notwithstanding that others had included props and backgrounds in cases holding taxidermy specimens (Trumbull, 2006:3).

Along with Akeley, two other noted taxidermists William T. Hornaday, director of the American Museum of Natural History in 1911 and F. A. Lucas, director of the New York Zoological Park in 1896, were the chief architects of the habitat group/diorama movement in United States. In the mid-1880s the American Museum of Natural History displayed the first bird groupings, surrounded by lifelike leaves and flowers made from wax. The curator of ornithology at the AMNH Frank Chapman (Collins, 2003) is thought to have pioneered the modern scientific approach to dioramas in North America. In 1901 the museum installed a series songbird exhibits in the Hall of North American Birds in very detailed and realistic nesting situations with painted backdrops. These displays were created under the direction of Chapman and were so well received that other exhibits on a larger and more elaborate scale, such as the popular Egret Group and Pelican Group, were soon to be completed. Egrets and Pelicans were severely threatened at the time and the exhibits were intended to convey a strong conservation message (Wonders, 1993). In the same year that Chapman completed his earlier bird exhibits, Carl Akeley completed his four-seasons

Virginia Deer Group at The Field Museum in Chicago. A contemporary article in *Time* magazine praised Carl Akeley's Hall of African Mammals at the American Museum of Natural History for its "...zoo-like panoramas" (*Time* 1942 cited in Coe, 1986:3).

The great period of museum dioramas and habitat groups had begun and would last for the next 40 years until World War II. The popularity of dioramas among museum directors, if not the public, diminished due to the great expense involved with their creation. This contributes to discourage curators from constructing new dioramas that so periodically come into and out of fashion as, indeed, does the highly skilled artistry of taxidermy (Tunnicliffe and Reiss, 2007:1). Carnegie Museum of Natural History at Pittsburgh and Peabody Museum of Natural History at Yale are examples where diorama collections maintain their renowned status. Denver Museum of Nature and Science also has a great collection of dioramas. The natural history museums in Edinburgh and Malta have both recently installed brand new habitat dioramas.

Group displays became internationally associated with natural history museums during the twentieth century and are among the most renowned three-dimensional didactic depictions in the sciences. The displays come in many varieties, the simplest typically showing mounted animals of a species (a male, female and young) positioned in characteristic poses and unburdened by scenery. The more elaborate 'habitat groups' show animals in a meticulously reproduced naturalistic setting that includes characteristic features of their environment such as plants, rocks, water or a leaf-covered forest floor. Habitat dioramas are the most elaborate of these 'groups' that include a background fading into a three-dimensional scene such that the viewer's eye is drawn into the scene as a whole (Nyhart, 2004: 307).

Some dioramas are over a century old, but they are still much appreciated for their importance in contributing to visitor's understandings of conservation and taxonomic biology (Scheersoi and Tunnicliffe, 2009). Dioramas that have been in place for many years could still be useful since these show past activities that reflect realities of our times, such as past human polluting activities and global warming or diminishing wildlife (Insley, 2008:30-31). Habitat dioramas have a potential longevity since they present a natural setting that changes slowly or is perceived by visitors to be preserved as shown. It might be the case that the organisms could be extinct and their environment substantially depleted and can thus act as records of actual habitat such as Akeley's African Dioramas at New York.

Habitat dioramas are full-scale, realistic representations of creatures that were alive. Natural history dioramas are increasingly appreciated, as a special genre of museum exhibit, and their key role is increasingly acknowledged by various museum professionals (Tunnicliffe and Scheersoi, 2009). Taxidermists construct a fibreglass body and fit the real animal skin onto it. Wire frame and wood is used to construct trees, rocks and landscape features. The diorama's integrated tableau of animals with their surroundings helps bring natural history to 'life', yet at the same time it exposes human attitudes toward nature. Therefore, habitat dioramas are not simply imitations of the biological landscape, but perform a function in the cultural construction of our world. The early diorama showpieces of the large natural history museums contributed to the process by which Europeans and Americans established their relationship with nature at home and abroad (Wonders, 2003: 89).

Despite their slow growth, the volume of educational literature on dioramas remains limited. They are absent from the indices of major texts on museum learning such as Hein (1998), Falk and Dierking (2000), Paris (2002) and Black (2005). Literature mainly consists of studies that look at what visitors learn from dioramas (Ash, 2004; Peart and Kool, 1988; Reiss and Tunnicliffe, 2007; Scheersoi, 2009; Tunnicliffe, 2005 and 2007) while less specific studies outline the historic, taxidermic, taxonomic and conservatory value of habitat dioramas (Morris, 2003; Quinn, 2006; Wonders, 1993). Various possible uses for dioramas have been suggested as far as serving as repositories for DNA. This work focuses on the potential of dioramas as sites for biological learning, more specifically the diversity and form of animals and plants.

2.5 Learning at Natural History Dioramas

Various researchers have recently documented the educational potential and role in biological learning of dioramas (Ash, 2004; Insley 2007, 2008; Peart and

Kool, 1988; Piqueras et al., 2008; Reiss and Tunnicliffe, 2007; Scheersoi, 2009; Tunnicliffe, 2002, 2005 and 2007). At dioramas, learning occurs through imagery in the iconic mode, which is a 'more concrete way of learning' (Hooper-Greenhill, 1994: 144). These displays potentially provide precious opportunities for education in museums (Paddon, 2009: 26). Discussions that take place at the dioramas embody basic science processing skills: observing, communicating, classifying, inferring, and hypothesizing. Skilfully constructed natural history dioramas can still provide a significant opportunity for fundamental acquisition of science knowledge (Stern, 2009: 15). The habitat diorama played a leading role 'as a tool for science education' in achieving the AMNH's 'mission and focus as an education institution' (Quinn, 2006: 10).

Our time of increasing interest in conservation and biodiversity calls for an expansion of natural history or habitat dioramas. These museum exhibits are still greatly cherished in America, but are struggling to sustain this appeal in British natural history museums. The Natural History Museum in London has dismantled the dioramas of African animals and their habitats once located in the Rowland Ward Pavilion. Habitat dioramas offer a prospect to visitors to observe different habitats, categorise organisms and raise personal questions. Dioramas also serve to provide snapshots in time of past habitats and can be used to show how endemic flora and fauna have changed over centuries and according to different climatic conditions. This is adequately shown by the recently opened dioramas at the Beginnings Gallery in the Museum of Scotland, Edinburgh that show the development of the fauna and flora of Scotland from the last Ice Age (Tunnicliffe, 2006: 100).

The declining populations of wildlife and increasing urbanisation are reducing the opportunities for children's direct experience of wildlife outside school, raising worries that the next, largely urbanised generation will have scarce knowledge and interest in wildlife (Huxham et al, 2006:9). This is not to say that there is no wildlife in the urban environment. Birds like pigeons and sparrows are common and widely present, other animals such as lizards and geckoes are less conspicuous. People in general are more knowledgeable about the wildlife they come across in their everyday lives. Malta is a small archipelago that possesses sparse endemic wildlife and over a third of its surface area is occupied by building. There are no zoos or major animal parks. The only places where live animals can be seen on display are commercial farms, a petting farm, falconry, a small bird park and one or two public places that have a lama and a kangaroo.

In such a situation, dioramas are particularly valuable for the urban community to be able to see and possibly understand the diverse habitats with the various organisms that live within (Tunnicliffe, 2005:30). 'At their best they are one of the most powerful techniques for emotional access and effective learning' (Insley, 2007: 33). Habitat dioramas can serve as a unique and powerful science education resource and unrivalled as a tool in biological education mainly because:

> *'The organism can be viewed, unlike the situation in zoos, in particular where animal may be hiding or off display. Moreover, the organisms are shown in an accurate simulation of their natural surroundings enabling information and concepts about interrelationships between both organism and their habitat to be made' (Tunnicliffe, 2005:30).*

School children of all ages learn more about animals and plants from the people closest to them such as their family and friends and out-of-school observation, than they do from schools, books, television and other media recognise (Carrier Martin 2003:51, Reiss and Tunnicliffe, 1999:14, Tunnicliffe, 2006:99). Places such as natural history museums, botanical gardens, zoos and nature reserves as well horticultural gardens and farms, have a central role to play in learning about the organism and their interrelationships. Visits to collections of organisms at such places are also part of the primary school tradition.

> *"Natural history dioramas are an exceptionally effective medium for learners to acquire elements of biodiversity information such as the habitats of particular animals, interrelationships of organisms as well the attributes which define their names and hence their taxonomy" (Tunnicliffe, 2007: 7).*

Natural history dioramas are still an underutilised educational resource and have been dismissed as old fashioned and irrelevant by non-educator management officials enticed by effective technological innovations. Dioramas are a powerful potential tool in science education and should be developed as such (Tunnicliffe, 2009: 20). Dioramas have great potential for learning in Biology, particularly in aspects of biodiversity, ecological relationships and ecosystem ecology.

When properly designed, dioramas allow lone visitors and small groups to carry their own interests to the exhibit and to connect with them in a way that provides a measure of control (Tunnicliffe and Reiss, 2007:1). Through their 'stillness', dioramas offer opportunities to "stand and stare" and serve as a focus for biological understanding in an out-of-school environment. Dioramas potentially motivate visitors to stay longer at an exhibit and to facilitate their understanding of the object's functions, meanings or associations. Visitors may also relate their previous experiences to the scenes and artefacts presented in the diorama, which thus become 'appealing, invite exploration and therefore facilitate learning' (Scheersoi and Tunnicliffe, 2009). Research in natural history museums (United Kingdom, Germany and Malta) indicates that young animals, big or dangerous animals and unexpected settings particularly attract visitor attention.

The next chapter 3 is a literature review relating to the conceptual framework for the research. I briefly discuss constructivism and social constructivism and their relation to learning about nature. I also discuss informal learning, implications of field trips and theory relating to perception, visualization and mental models. The chapter concludes with a detailed discussion of Activity Theory.

3 Theoretical Concepts

I then consider informal learning in science and its relation to museum learning and the potential of dioramas as tools for biological learning. Children's drawings are of crucial importance and so I provide a comprehensive consideration to the concept of mental model, and the development and cultural aspect of drawing. The concept of visualization in science is also treated and drawing as a means of probing understanding. The second part of the chapter deals with informal learning, the dynamics of museum visits and field trip preparation, theories of perception, visualization in science and mental model. The chapter concludes with a brief review of the existing interpretation models and a detailed discussion of the chosen Activity Theory on which I base my novel Interpretative Model presented in chapter 6.

3.1 Conceptual Framework

The sociocultural and the constructivist frameworks inform my research here. Lev Vygotsky's sociocultural model of learning is based on learning and child development as they are affected by social and cultural factors. In social constructivism personal learning is controlled by knowledge and practice structures that already exist and are culturally defined. On the other hand, Piagetian constructivist theory of learning holds that children, with their internal processes, 'actively' construct their knowledge of the world. In the Piagetian personal and cognitive dimension it is the individual creation of knowledge and construction of concepts that prevail, while in the social dimension as explained by Vygotsky and Driver it is the importance of the group, for the development and validation of ideas, which is stressed (Sjøberg, 2010: 485-490).

Although constructivism and socioculturalism may be considered to have distinctly different histories and philosophies, the merging of these two perspectives is gaining ground. Learning in a constructivist manner may be understood as the building and refining of mental models, however also acknowledging the importance of social interaction in developing these models. The link between constructivism and socio-cultural theory is interesting due to its potential to explain children's development of knowledge in terms of its individual and social construction under the influence of social and cultural practices (Jaworski, 1996: 6).

As meaning is constructed in and through culture, meaning is influenced by our place in history and our own culture (Hooper-Greenhill, 1999: 13). The brain processes information on the basis of already existing 'schemata' or mental knowledge maps. As each person has their own mental maps of knowledge depending on their prior cultural and biographical experiences, each person will process new matter in ways that are specific to them as individuals. The construction of meaning is partly shaped by prior knowledge and experience, and by how the past is related to the present (Hooper-Greenhill, 2000: 118-119).

Perhaps Falk and Dierking (2000) offer the most explicit combination of the two theoretical perspectives in their Contextual Model of Learning (CML), which states that learning is personally, socially, and physically situated. I will highlight the basic tenets of constructivism and socio-culturalism.

3.1.1 Constructivism

Theories of learning are mainly informed by whether reality and all knowledge of it is revealed to, not invented by, the observer (Realism) or whether knowledge is thought to consist of ideas constructed in the mind (Constructivism) (Hein, 1999: 73). The term constructivism currently features in a wide range of educational literature and it has been given an array of different interpretations. In summary, constructivism is based on the notion that each individual constructs a unique picture of the world. The person must go through a mental process to be able to interpret and make sense of surroundings (Gatt and Vella, 2003: 4). The constructivist approach strives to develop the personal ideas of children (Driver, 1983). The meaning and understanding constructed may vary widely as influenced by background, experience, interests and knowledge that visitors bring to the experience (Anderson, 2012: 17).

Fosnot (1989) draws on Piaget in stating the four foundational principles of constructivism:

a) Knowledge consists of past constructions.
b) Constructions come about though assimilation and accommodation.
c) Learning is a creative process, more than a accumulation of facts.
d) Learning occurs through reflection and resolution of cognitive conflict.

Despite their differences and disagreement about what the term denotes, various proponents of constructivism share a common heritage in Piaget's theory. Science educators are increasingly adopting constructivism as the basis for research and curricular recommendations. For Piaget coming to know involves the successive detachment from one's own subjective perceptions so that an abstract representation of reality may be constructed. This lack of any consideration of human subjectivity in the process of construction is considered to be a major shortcoming in Piaget's Theory. Critics have taken serious exception to Piagetian 'progressive decentration' and argue that knowledge is socially constructed (Leach and Scott: 2003: 92; Lemke, 2001: 298; O'Loughlin, 1992: 793;).

> *'Furthermore, they argue that knowing is a dialectical process that takes place in specific economic, social, cultural, and historical contexts'* (O'Loughlin, 1992: 799).

3.1.2 Constructivism and museum learning

As a constructivist one could set out to see how the child constructs knowledge about animals and plants through interactions with habitat dioramas. When children are allowed to interact with the dioramas, they stop to observe, notice the different forms of animals and plants, the anatomical features of each organism and possible relationships between animals and plants or animals and animals. The child forms his or her concept of animals and plants in general and more specifically a concept of the particular organisms featured in the exhibit. The constructivist approach would be to elicit the concept formed. The social constructivist would consider the role of culture and of peers as children interact in groups.

The act of knowledge acquisition is itself constructive and viewers in a museum construct personal knowledge from exhibits. Opportunity is afforded to make meaning of experience by connecting with what is already known and to compare the unfamiliar and the new (Hein, 1999: 76).

> *Visitors come to the diorama on their visits with some knowledge relevant to the content in most cases. In their view their knowledge is pertinent to the exhibit and they often use this and only this on their interpretation of what they see (Tunnicliffe, 2009: 16).*

The concepts taught to primary children need to be relevant to everyday life and their experiences should be such that the children can be actively involved in the generation of their learning. Dioramas may be studied from a constructivist and social constructivist perspective. Children construct their own personal knowledge, but they also construct knowledge as they interact with museum exhibits as a group.

3.1.3 Socioculturalism

L. S. Vygotsky's thoughts are at the core of the sociocultural perspective and to him all learning was social. He meant social in the sense that ideas and concepts are often mediated by more experienced learners; that learning takes place in a context which may well be social in origin; that learning builds on previous learning; and that learning takes place primarily through cultural and psychological tools (Smidt, 2009: 14). Vygotsky's first principle is based on the assumption that mental processes cannot be understood when taken out of their original social context. His second principle is that individuals' psyches are fusions of their social interactions.

Lave (1988) and Wertsch (1991) both presented their theoretical perspective on the concept of teaching and learning as socioculturally situated activities. Lave argues that meaning making is a dialectical interaction between person, activity and setting in a given context. This is a form of constructivism that underlines the subjectivity, the sociocultural positioning and the intrinsically dialectical nature of the process of acquiring knowledge. This theory has the power to address issues such as cultural diversity, power, context, subjectivity, and social transformation that are all beyond the reach of Piagetian constructivism (O'Loughlin, 1992: 810).

Drawing on Vygotsky and Bakhtin, Wertsch argues that the central link between the thinking of the person and the influence of the social, cultural, historical, and institutional setting in which the person lives is the mediational means the person uses to engage in the construction of meaning. For Wertsch (1991), as for Lave, the person is not seen as a decontextualized individual, but reasoning is conceived to be an inherently social and cultural process of meaning making. He argues that it is firstly social because the development of understanding is necessarily dialogical and requires interchange of ideas, and secondly culturally framed because any frames of reference we bring to bear, and any language forms we choose to use, are sociocultural in origin, and come to us burdened with their share of culturally laden significances.

According to Wertsch (1991), “the basic tenet of a sociocultural approach to mind is that human mental functioning is inherently situated in a social interactional, cultural, institutional, and historical context” (p. 86). All social animals have basic observational skills (lower mental functions), and humans have developed language and other social tools that enable greater communication and learning (higher mental functions) between people. These tools have allowed humans to create knowledge and complex systems to distribute and access this knowledge. Since social tools are malleable, the social context of a situation must be accounted for before the functions of the mind associated with it can be understood. This is in direct opposition to the psychological premise that human learning can be explained and studied separated from the cultural circumstances in a decontextualized context.

Mediated action[1] is central to a sociocultural approach to learning. Action differs from behaviour, in that action refers to the intentional and purposeful, while behaviour also includes the subconscious and reflexive. Mediated action is action that results from the interplay of the intra-mental and the inter-mental planes, the self and another mind or a tool. We initially have experiences in an external social setting and in cooperation with other people on the inter-mental plane. We then individually internalize these experiences on the intra-mental plane. The social context comes first, and then learning can take place within these contextual boundaries (Leach and Scott, 2003: 99; Phillips, 2011: 109; Scott Frisch, 2011: 28).

[1] A mediated action is defined as a social action taken with or through a mediational means (cultural tool). All social actions are construed as mediated actions, it being definitional that ‘social’ means socially mediated. The principal mediational means (or cultural tool) of interest is language or discourse, but the concept includes all objects in the material world including other social actors. Within MDA there is no action (agency) without some mediational means (i.e., the semiotic/material means of communicating the action) and there is no mediational means without a social actor (agency).

The study of mediated action deals with how humans use cultural tools (mediating tools) when they are involved in various forms of action. The cultural tools may have various forms such as simple mnemonics, like marks on a stone, to natural language and computers. The kind of action involved may be socially distributed or carried out by individuals. At the heart of analyses of mediated action is an irreducible tension between cultural tools, on the one hand, and agents' active uses of them, on the other. In understanding mediated action, it is not the participant that is of interest, nor the tool that they are using, but the complex, dynamic interplay between the two that is at the heart of the sociocultural approach (Wertsch, 1998).

3.1.4 Sociocultural Perspective on Science Education

To take a sociocultural perspective on science education basically means considering science, science education, and science education research as human social activities conducted within institutional and cultural frameworks. Teaching concepts detached from their social, economic, historical, and technological contexts would be a distortion of the nature of science and concepts taught would be relatively useless in life, however well they may seem to be understood on a test.

Students and teachers need to understand how science and science education are always a part of larger communities and their cultures, including the sense in which they take sides in social and cultural conflicts that extend far beyond the classroom (Lemke, 2001: 301; O'Loughlin, 1992: 816).

In socioculturalism, discourse analysis and language is the predominant, but not only cultural tool; science and science learning are characterized by their rich synthesis of linguistic, mathematical, and visual representations (Lynch and Woolgar, 1990 in Lemke, 2001: 298). The mediational means should not be viewed as some kind of single homogeneous whole, but rather in terms of the diverse items that make up a tool kit (Wertsch, 1991: 118).

3.1.5 Drawings in the sociocultural perspective

Drawing is one of humankind's oldest cultural tools as a meaning making technique. Making a drawing of some object, event or living thing is a universal ‘meaning making’ human activity (Wright, 2010: 64). Drawing in early childhood is problematic. Despite a growing interest in young children’s drawing, many barriers to the adequate support of drawing for young children remain. There is a lack of adequate frameworks for examining drawing and the drawing process. Two dominant discourses underpin our understanding and responses to drawing: one derives from Piaget’s developmental learning theory and the other from aesthetics. Neither seems to serve us well and a Vygotskian socio-constructionist framework might be more appropriate to help us understand young children’s drawings. Piaget proposed a consistent, universal, sequential progression in children’s drawing over which the adult had little influence. His developmental framework is based on such things as “draw a person” tests as benchmarks for children’s cognitive development. It is argued that such ‘disembedded’ analyses of children’s drawings do not effectively show the intentions of the child or the social and cultural context in which the drawing was done.

The aesthetics semantic belongs to the realm of art professionals and while this lens might be applied to young children’s drawing it often denies the contexts and the intentions of the children. Aesthetics doesn’t address the various problem-solving and meaning-making activities that are inherent in the drawing process by young children (Brooks, 2009: 320). Developmental research on drawings is extensive, but there is minimal presence in the sociocultural literature (Phillips, 2011: 109).

If we examine drawing from the Vygotskian perspective, the pencil and paper are historically and culturally developed tools or artefacts used by humans in the mediated action of drawing, which means interacting with the social and physical world. The visual, observed world is external, but when we see, experience, and understand it, we can internalize or learn it by drawing. In art education, but even more so in the school subject of science, observational drawing is a well-established activity, reflecting the accurate visual study and drawing process of trees, flowers, birds, and human organs (Scott Frisch, 2011: 34).

Examining the process of young children's drawing through a Vygotskian lens could lead to the development of a more useful theoretical framework for looking at both the process of children drawing as well as their scientific thinking through their drawing. We might also begin to better understand how the visualization of ideas and concepts through drawing can support young children's scientific ideas and higher mental processes (Brooks, 2009: 323).

The empirical work in this thesis is based on drawings produced by 9-year-old primary school children in Malta. The drawings are an expressed model of the knowledge constructed and a detailed analysis shows the manner and extent of such knowledge construction.

3.2 Informal Learning

In informal learning situations children are more likely to experience differing knowledge and understanding and prior learning may be more relevant to the situation than in school. Each child may have different access to different areas of knowledge through their varying interests and exposure to sources such as television, books or the internet. Informal learning settings also allow children greater free-choice to explore exhibits and construct new learning influenced by prior knowledge (Bowker, 2007: 77).

No definite agreement exists in literature on what informal learning should be understood to mean. Traditionally, formal learning was understood to be characterized by a highly structured environment, while informal learning occurred in less structured environments where the control of learning shifts from the teachers to the students. This distinction is too sharp since it refers to the physical setting, which is just one factor that influences learning (Eshach, 2007: 173). Valerie Crane defines informal learning as:

> *"activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an on-going school curriculum and are characterised by voluntary as opposed to mandatory participation as part of a credited school experience." (Crane, 1994: 179).*

Other factors such as motivation, interest, social context and assessment are required to distinguish between three types of learning: formal, informal, and non-formal. Non-formal learning may occur in a structured and planned manner in places, institutions and situations, such as museums, outside the scope of formal and informal education. Motivation is typically intrinsic to the learner and mediated by an educator or institution official. Informal learning is unstructured and spontaneous, and normally distinguished from the other two in that there is no authority figure or mediator (Eshach, 2007: 173). It is recognised that the public continuously acquires science information across the day and throughout their lives. School-aged children utilise a wide range of non-school sources for constructing their science understanding. While still primary school focused, NSTA has recognised the importance that free-choice learning plays in science education. It is also a sign of the growing awareness that public science education occurs not only in schools, but also museums, science centres, zoos, aquariums, on television, radio, the internet, hobbies and social activities, and various community settings and situations (Falk, 2008: 245).

Learning opportunities are not limited to the time spent in school, but also occur on weekdays and weekends, morning, afternoon and evenings. Free-choice learning is by no means exclusive to the non-school environment. Good classroom teachers understand the importance of providing students with choice and control over their learning. The strength of informal education programs is their emphasis on free-choice learning, active engagement of learners in the scientific process and promotion of inquiry. Their weaknesses are mainly the lack of follow-through and commitment to long term, extended investigations. Informal learning programs normally do not allow learners to continuously build upon their learning over time (Eshach, 2007: 174). Table 1 that follows presents the distinguishing features of formal, non-formal and informal learning.

Table 3-1. Formal, non-formal and informal learning (Eshach, 2008).

Formal	Non-formal	Informal
Usually at school	At institution out of school	Everywhere
May be repressive	Usually supportive	Supportive
Structured	Structured	Unstructured
Usually prearranged	Usually prearranged	Spontaneous
Motivation is typically more extrinsic	Motivation may be extrinsic but it is typically more intrinsic	Motivation is mainly intrinsic
Compulsory	Usually voluntary	Voluntary
Teacher-led	May be guide or teacher-led	Usually learner-led
Learning is evaluated	Learning is usually not evaluated	Learning is not evaluated
Sequential	Typically non-sequential	Non-sequential

The categorisation provided above is perhaps too generalised and extreme in defining what is formal, non-formal and informal. If formal is meant to be structured learning within a school, it does not have to be repressive or teacher-led.

There was concern about the crossover between formal and informal learning since informal learning practitioners felt that the formal system had essentially failed and that partnerships between the two systems could force informal learning to transform itself into schooling (Crane, 1994: 189).

Museums may serve as venues for non-formal as well as informal learning for children, adults and senior citizens alike. School visits to museums are opportunities for non-formal learning where the teachers and museum staff exert some control over the pupils in a prearranged and structured setting. Ideally the pupils should be free to experience the museum exhibits, as they desire, but without chaos.

3.2.1 Informal learning in science

We are just starting to understand how children's informal knowledge of biology may affect or could be affected by science instruction. Three fourths of Nobel Prize winners in science, report that their passion for the subject was first sparked in non-school environments (Falk, 2008: 245). Lifelong science literacy is not sufficiently supported by schooling alone. It is a critically important to understand the relationship between formal and informal learning and how cultural knowledge, values, and models could impact on such learning (Medin and Atran, 2008: 141).

The nature of science and how it works goes beyond the simple exploration of content specific concepts and regurgitation of scientific facts (McComas in Melber and Abraham, 2002: 49). Falk and Dierking (2000) have pioneered a model that aids in understanding how learning occurs in informal settings. This model can be applied to situations where individuals have an element of free choice in what they learn. They called it the *contextual model* that combines the personal, sociocultural and physical contexts and how these interact in learning. The personal context comprises the four aspects; intrinsic and extrinsic motivation, personal interest, constructivist notion of learning and expression of learning within appropriate contexts. The sociocultural context should be considered since our culture influences the way we act in and respond to various learning situations. The ways in which we are brought up impart social norms that set expectations and rules on our behaviour and learning. The sociocultural context of learning depends on the level of engagement with exhibits that is principally affected by the museum environment, or so called physical context. The sights, sounds and smells encountered in museums have a significant impact on the type of experience and so the level of learning that takes place (Braund, 2004: 115-117). The sociocultural context embraces two factors; 'within-group sociocultural mediation' and 'facilitated mediation by others'. Social groups in museums relay on each other as instruments for interpreting information, strengthening shared beliefs and making meaning. Socially mediated learning is not limited to the individual's own social group, but can also occur with strangers who are considered to be knowledgeable. (Falk and Dierking, 2000: 138-139).

Some legislators suggest that people must choose between classroom-based education and experiential education beyond the classroom walls. However, this is a false choice since both deserve more support (Louv, 2008: 138). Finland, that boasts enviable results in education, encourages environment-based education and has moved a substantial amount of classroom experience into natural settings or the surrounding community (Louv, 2008: 205).

In this research, children observe habitat dioramas and interact with them in peer groups of four to five pupils. Their peers and the cultural milieu they bring with them to the museum mediate the interaction with the exhibits. Research with family groups has produced much of the knowledge about learning behaviours of children during museum visits. Adults tend to set the agendas of visits with children according to what they think their children's interests are.

3.2.2 Dynamics of a museum visit

Stronck (1983) found that a more structured tour on a novel field trip did not necessarily result in an increased positive attitude and increased achievement, in part confirming conclusions from previous studies (Falk, Martin and Balling, 1978: 7) that novel settings may interfere with learning. Novelty is an extremely important educational variable that educators need to exploit to boost educational objectives. The novel field-trip factor should not be viewed as a barrier to overcome before actual learning can occur, but rather as an interaction between the child and his environment.

The OFSTED (2008) report on English schools states that 'One of the attractions of learning outside the classroom was that everyone behaved well because they were motivated and active' (pg.22). However it would seem that this also depended on the preparation and control of the individual class teacher. When learning outside the classroom is an integral part of the curriculum, this alleviates the demands on staff for planning of educational objectives and the practicalities of the visit (OFSTED, 2008: 22-24).

A study by Benz (1962) recognized that, 'part of the pupils' time was given to "looking around," perhaps at the expense of the knowledge of the geology they were on the trip to acquire' (pg. 49). The results of the study by Kutoba and Olstad (1991) showed that 'novelty-reducing preparation' results in increased on-task exploratory behavior and greater cognitive learning in boys, but that the novelty-reducing treatment was not effective on girls' (pg. 231). It is suggested that repeat visits significantly improve learning (Falk and Balling, 1980).

Most effectively managed schools and colleges in England included learning outside the classroom as an integral part of a well-planned curriculum (OFSTED, 2008: 4). Dierking (1991) argues against a sharp distinction between ‘formal’ learning that occurs in schools and ‘informal learning’ that occurs in museums. In-school and out-of-school learning experiences are at the ends of a continuum that requires bringing classroom science and everyday life closer together. The continuum perspective moves away from the traditional dichotomy of formal versus informal learning and is more in-line with Falk’s (cited in Tal and Morag, 2007) idea of choice opportunity, since the faculty to choose what to learn is not exclusive to non-school environments (Tal and Morag, 2007: 749).

Students rarely discuss ideas and get little time to freely explore the exhibit. A general conclusion from two studies is that the vast majority of museum visits were guide-centered and lecture-oriented activities (Cox-Petersen et al., 2003: 215, Tal and Morag, 2007: 766). During a school fieldtrip students have little control over the day’s agenda. The teacher plays a vital role in a museum visit and the educational worth of a museum fieldtrip may be heavily dependent on the instructional strategies of the teacher leading it (Kisiel, 2006: 435). The visit will be meaningful when students are encouraged to investigate exhibits on their own and in small groups (Falk and Dierking, 2000; Hein, 1998).

Stronck (1983) found that students on the unguided tours found the museum to be more exciting, less confusing, better and more useful. Although the majority (50%) of students preferred a docent as their teacher when visiting the museum, a large group (24%) of students preferred to teach themselves in the museum without any assistance. Students also wished that they could touch and feel more things (Buttigieg, 2001: 55).

In the England OFSTED (2001) established a set of national standards for out of school experiences intended to act as a “set of ‘outcomes’ that providers should aim to achieve” (pg. 3). Together with achieving the National Standards, the providers are also expected to follow a set of regulations given in the same document. The OFSTED (2008) report entitled *Learning Outside the Classroom*, evaluated the impact of out of classroom learning in 12 primary, 10 secondary, a special school, a pupil referral unit and 3 colleges. The report gives recommendations on how schools could be better supported and encouraged in enriching the quality of out-of-class learning and on how the schools could provide meaningful out-of-class experiences for all their students. Teachers could feel uncomfortable and unconfident in out-of-class settings if they lack the basic scientific knowledge and understanding needed to support the pupils (Buttigieg, 2001: 56).

> *'In the best primary visits, staff, parents and other volunteers supervising the pupils were given clear guidance about the expected learning and how to promote it, for example by asking key questions. However, this was not always done well, with the result that the focus on learning in the minds of adults and pupils was diluted'* (OFSTED, 2008, pg.15).

All learners involved in the survey found working away from the classroom 'exciting', 'practical', 'motivating', 'refreshing' and 'fun'. Following a class lesson, pupils became animated and involved once they had the opportunity to conduct their own research outside the classroom (OFSTED, 2008: pg.10). A study carried out at Dar il-Lunzjata science center in Gozo highlights the pupils' enthusiasm, involvement, quest for knowledge, desire to try things, enjoyment and excitement during a visit to the center (Buttigieg, 2001: 55).

3.2.3 Trip preparation and teacher involvement

Literature highlights the characteristics and requirements of successful educational experiences in informal learning environments. There are six psychological needs of museum visitors for a) curiosity, b) confidence, c) challenge, d) control, e) play, and f) communication, all of which must be met for a museum experience to be successful and educational (Perry, cited in Patrick, Mathews and Tunnicliffe, 2011: 5). Davidson, Passmore, and Anderson (2009) identified and defined the following four characteristics or implications of successful field trip design: 1) Planning, 2) Visiting the facility, 3) Making the field trip fun, and 4) Combining student and teacher led learning. Successful field trips warrant cautious planning and could significantly impact on student learning when teachers integrate pre-visit, during-visit, and post-visit classroom teaching into the field trip (Hooper-Greenhill, 2000; Parsons and Breise, 2000). Pre-service teachers concluded that when teachers prepared their students properly before a trip, less time would be spent on management and more would be spent on learning (Patrick et al., 2011: 20). OFSTED (2008) reported that most head teachers acknowledged that organizing learning outside the classroom could be hindered by concerns about pupils' behaviour.

Teacher involvement can vary dramatically from teachers disappearing into the cafeteria after delivering their charges to the museum staff to active engagement in all phases of the program (Kisiel, 2006: 435; Price and Hein, 1991: 512). Various studies show that most teachers do not plan the visit, are not aware of the program of the day, and do not understand their role as important for the success of the visit. The majority of elementary school teachers were either passive or provided only technical help (Tal and Steiner in Tal and Morag, 2007: 766; Tal et al., 2005: 932). The majority of the teachers fail to identify the reasons for their visit. One reason for this is the fact that most of the teachers are sent by someone else at school to supervise their students. Another reason could be that teachers perceive the field trip as a fun event and not as a meaningful educational experience. On other hand, committed teachers may face pedagogic dilemmas. In one case, a teacher was dubious whether or not she should go back to get the boys who had wandered ahead or just let things happen as they did. She described a conflict between a desire to teach, and wanting the students to see the museum as a fun, informal place where you can learn (Kisiel, 2006: 446).

Organizing a field trip can be such a daunting task for teachers that the pedagogical aspect of a 'museum' visit may suffer (Storksdieck, 2001: 8). Teachers struggle with time constrains, logistical issues, student responsibility and pressures of accountability that all dampen their willingness to provide proper preparation and post-visit activities (Tal et al., 2005: 921). Regardless of cause, the apparent effectiveness of teacher strategy is clearly impacted by time (Kisiel, 2006: 447).

Schoolteachers accompanying their students to the museum can help to mediate the activity in three main patterns: (a) the guide's initiative, which was mainly with regard to technical issues; (b) the teacher's initiative, where the teacher played an active role in the pedagogy of the visit, either by clarifying terms or by referring to topics and ideas discussed in school; and (c) no mediation, where neither the guide nor the teacher made an attempt to help the students in their assignment or to connect the lecture to the school science (Tal and Morag, 2007: 763).

3.3 Theories of Perception

The major theories of perception are: Gestalt Theory, Brunswik's probabilistic functionalism, Gregory's Theory, Gibson's Theory of direct perception, Marr's computational approach and the Neurophysiological approach. Gestalt (meaning organised whole) theory is based on the notion that while looking at the entire one is not conscious of the parts, but just aware of the overall picture. Parts are of secondary importance even though they are clearly visible. It is easier to remember items in an organised setting rather than isolated items on a sheet (Bradley, 2014). Brunswik's probabilistic functionalism holds that psychology should give as much attention to the properties of the organism's environment as it does to the organism itself. This is a theory that proposes environmental cues are only guesses regarding the objects they refer to (Hammond, 2001). Brunswik knew that visual images contain information that is basically ambiguous. His ideas have been criticized, but he was the first researcher to face up to the complexity of perceptual processes and to recognize the perceptual stability in an intrinsically uncertain world is a great achievement (Gordon, 2004: 67).

Gregory's Theory (constructivist) explains 'perception' as a chain of events given as follows: signals received by sensory receptors trigger neural events; these inputs are interacted with appropriate knowledge to generate psychological data; on the basis of such data, hypotheses are proposed to predict and make sense of events in the world. Gregory's theory is closer to Brunswik's than to the Gestalt since it resides within the empiricist paradigm and is more psychological rather than physiological. Possibly we are able to perceive constructively only at certain times and in certain situations. When we experience the natural world, the required perceptions of size, texture, distance, continuity and motion may all occur directly and reflexively (Gordon, 2004: 129).

Gibson's direct perception theory challenges the constructivist view that sensory inputs are too impoverished to mediate perception and so the perceiver must add to them. The essence of this constructivist paradigm is that perception of the world is essentially indirect; information must be added to the incoming stimuli before a final perceptual response is obtained. Direct perception theorists disagree that awareness is only indirect and that perception is mediated by internal representations. Unlike Gregory's and Gestalt theorists, Gibson sees real movement as a vital part of perception. He concluded that visual perception is extremely accurate. The essence of this theory is that under rural environment, there is a richness and structure in the various stimuli available to an observer, such that the world can be specified. Gibson did not think that his theory was applicable to perception of cultural artefacts (Gordon, 2004: 180). Marr's computational approach is that perception proceeds as an information-processing system and that this system is organised into successive stages: 1) the image; the retinal processing, 2) the primal sketch; raw intensity values of the visual image, 3) 2½ D sketch; a 'picture' of the world begins to emerge, and 4) 3D model representation; the perceiver has by now obtained a model of the real external world (ibid pg193). The neurophysiological approach is a major development using MRI technology. It's weaknesses are: 1) tendency toward reductionism and 2) language remains 'within' the organism. Little attention is afforded to the nature of the environment from which stimuli arise. Explanations at the neuro-physiological level cannot deal with the subjective nature of seeing. As Marr and others have argued, knowing that a neural system does something does not tell us why is does it. Neuroscience suggests that the human perceptual system is divided into two kinds, one dedicated to discover where things are, while the other discovers what things are. Whichever way environmental stimuli are perceived and represented in the CNS, externally they are represented in drawing, three-dimensional activities, dance-like and musical actions (Matthews, 2003:25).

In conclusion, Empiricism has to date been the most successful general theory of perception and it has dominated experimental psychology for over a century. This approach is based on the main belief that perception is a constructive process. However, are stimuli really so impoverished that the information associated with them needs to be supplemented by memory and reasoning?

Human perception occurs in two situations; a) Natural: surfaces and textures, solid objects, rich patterns of multisensory movement and change, and b) Human Culture: language symbols and 2D patterns as representations of 3D objects. The way in which perception engages with artefacts of our culture may differ importantly from the way in which it deals with the natural world. This becomes relevant to this research since it deals with museum artefacts, conceptual habitat dioramas, which are representations of typical local habitats (Gordon, 2004: 214).

3.3.1 The mental model

A representation is a likeness or simulation of some ideas, concept, or object. In learning we often use an external representation, found in the environment, to build an internal representation, held in the viewer's mind. However, unlike external representations, there is no tangible evidence and we cannot physically manipulate mental representations. Very often, we must convert our mental representations into external presentations. When it is called for, we retrieve our internal representations and attempt to reproduce them in some external form (Rapp and Kurby, 2008). The child's personal knowledge of a phenomenon or main features of an object are held in his or her mental model and when asked to draw, the child does so from the internal model (Cox, 1992: 88-91; Reiss and Tunnicliffe, 1999: 142). 'Visualization' is the meaning making for any such representation and is of crucial importance in science and science education. The development of fluency in visualization or 'metavisualization' is greatly desirable for anyone studying science. The ability to visualise (make meaning) a representation that is 3D, 2D, or 1D, is the key aspect of metavisualization (Gilbert, 2008: 3). Although visualizations are most often visual, they can convey information by using other sensory modalities, such as sound, smell and touch. Culture plays an important role, in the sense that mental models can be expressed and mediated through the cultural tool of drawing.

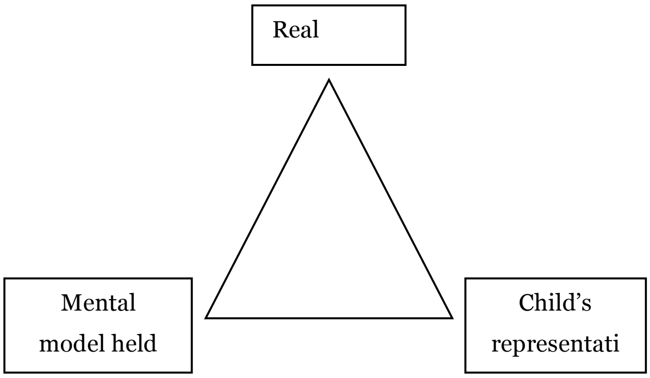
Visualization is of vital significance in science and science education since it enables meaning making of representations. Any pupil studying science needs to develop fluency in visualization or 'metavisualization'. The key aspect of metavisualization is the ability to visualise (make meaning of) a representation in the different special dimensions it may occur (Gilbert, 2008: 3). There are three sources of evidence to support the existence of metavisialization: a) a general 'spatial intelligence' seems to exist, b) a general model of memory capable of the application of visualization also exists and c) visualization is central in the process of thinking with memory inevitably employed (Gilbert, 2007: 15). During learning we habitually use external representations surrounding us to construct internal representations in our minds. However, we have no direct evidence of the existence of internal representations. We cannot physically manipulate mental representations to evaluate their validity. Often we are called to convert our mental representations into external presentations, such as during communication for example when writing a scientific paper or composing an email (Gilbert, 2008: 33). Observation, visualization and learning are closely linked.

However, a student does not simply retrieve a holistic mental replica of knowledge held in memory. Instead, the student retrieves elements of the partial representation he/she has stored of the object or concept (Rapp and Kurby, 2008). Other than the limits of our mental representations, an array of other factors constrain our reconstruction such as nature of the task, immediate context, our arousal level and mood, which may all effect how we build meaning from our incomplete knowledge structures.

What is being said can be followed and related to people talking or reading a book, or watching television if we can relay on a working model, a schema, in our minds that relates to what is being said. In novel situations, where no working model exists, talking and reading will not suffice. In learning new things, experience and action are required to construct a model (Hooper-Greenhill, 1999: 143). Dioramas may be used as a model to understand nature.

Children's learning about animals may be investigated by examining the mental models revealed through their talk and drawing when they come face to face with live or preserved animals. The mental model is the person's personal knowledge of the phenomenon. This knowledge will in certain aspects bear similarities and in others differences to scientifically accepted knowledge, which in the case of this thesis is the appearance of the organisms and their ecological habitat (Reiss and Tunnicliffe, 1999: 142). The features that capture children's attention may be revealed from the child's representations of the authentic specimens as constructed through the interrelation between the real object, mental model and the representation (figure 3-1).

Figure 3-1. Representation Construction (Reiss & Tunnicliffe, 1999)



(adapted from Reiss and Tunnicliffe, 1999:

The representations may be written descriptions, verbal descriptions, drawings or three-dimensional models. In this context, observation emerges as an essential skill for scientific learning, which is here understood to mean active looking in search of understanding (Tomkins and Tunnicliffe, 2006: 9). Tomkins and Tunnicliffe are particularly concerned that present day science education is lacking observation skills in biological sciences and stress the importance of the skill as follows:

> *'Children's observations attached to a search for underlying meaning develops their understanding in a topic, particularly in biological ones, and will encourage pupils to develop better science inquiry skills if they are allowed more time to look and ponder' (Tomkins and Tunnicliffe, 2006: 8).*

In another paper, the same authors note that the nature of observational practice is not well understood; even through it is one of the major underpinnings of all science processes. They also point out that meticulous observing and drawing of biological specimens was traditionally considered as an objective in itself, but did not always lead to creative thinking about the organism and its biology (Tomkins and Tunnicliffe, 2001: 792).

Corrado Ricci (1887) held that children's drawings are not an attempt to show the actual appearance of objects, but are expressions of the children's knowledge about them. Later Kerschensteiner (1905) argued that children include in drawings the main features of a concept belonging to a particular class of objects. Frequently children tend to ignore details and orientation and simply draw their usual scheme or formula for that type of object. Kerschensteiner repeated Luquet's claim "children draw what they know rather than what they see". The main facts or features of the object are held in a mental model and when asked to draw, children do so from the internal model (Cox, 1992: 88-91). Freeman (1980) states that "the child draws what he knows" should be replaced by "the child knows more than he draws" (cited in Krampen, 1991: 42).

While forming this internal model, children engage in a creative mental act rather than copy the object. By looking at the drawing, we can infer which features of the object are important to the child and which are less so. The content of drawing or writing is always a selection. It is neither possible nor required to represent all that is observed, known, remembered or visualised. Instead a drawing has to be considered as a symbolic language that can convey the meaning of a person's thinking, even if the drawing does not reproduce the thinking like a photo (Albery, 2000: 219). What is selected represents the person's immediate interest where features are not shown in their entirety (Cox, 2005: 75; Mavers, 2009: 265). Young children normally resort to intellectual realism when they are concerned that they wish their drawing to look realistic. Older children seem to understand that the purpose of the task is visual realism and are therefore more likely to draw what they see. Studies on child's internal model have taught us not to assume that children's drawings are print-outs of the internal representations that underpin the topics drawn (Jolley, 2010: 153). Children can pick up ideas from each other in the intimate situation at their benches that gives rich possibilities to look at each other's drawings and copy visual-graphic elements (Hopperstad, 2010: 447). According to Kress (1997) children never 'merely copy' (p. 37) and that meaning-making is always a transformative process even when copying.

Why should children be criticised for drawing images not as they really look? How do things 'really' look anyway? Such criticism seems to imply that there is just one true reality that exists independently of the modes of representation used to describe it. Representation is a human construct rather than being a copy of reality that exists independently of human forms of representation (Cox, 1992: 179).

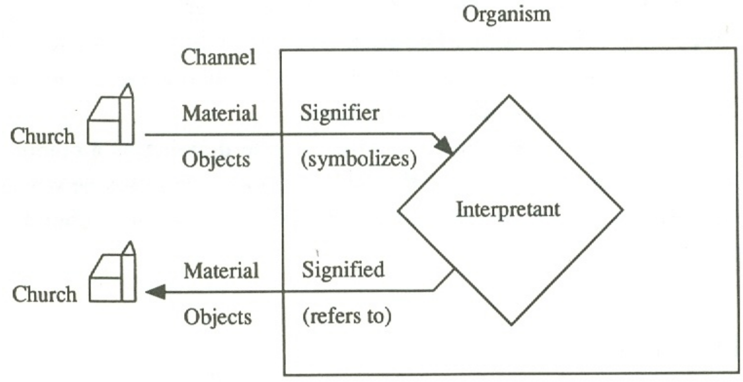
In interpreting children's drawing, we need to understand what they signify to the child. Atkinson (2002: 17) argues that drawings may be usefully considered as semiotic processes and structures which children organise and construct for signification reasons or representational purposes. Representation can be understood in the strict sense of 're-presentation', in a formal structure of a previous observation or experience of things or events in a way that these will be recognisable in represent. If a drawing is an effective representation one must be able to recognise in it the actual outlines of the items that the drawer intended to represent. Also, "the drawings of young children are as different one from another as are fingerprints, yet they can be classified (Golomb, 2004: 357)".

Gardner proposed the idea of spatial intelligence, a set of skills and abilities connected with the visual world. Although it is considered to be an inherent capacity, the development of spatial intelligence depends on culturally determined factors. From birth, children encounter a wealth of information out of which they need to make sense and build their own system of understanding. Visits to places such as museums could offer children the opportunity to practice spatial skills that may be evaluated in drawings they produce. Jean Piaget described a scenario for the development of spatial intelligence as part of his studies on the development of a child's mind across different cognitive domains. Piaget defined the basic elements, which characterise the skills connected with spatial intelligence. He followed the principal stages defined by Luquet (synthetic incapacity, intellectual realism and visual realism) while studying the development of space perception in children's drawings. The new scientific interest in the development of the mind resulted in a growing interest in children's drawings by educators and scientists from different disciplines.

One belief about children's visual representation is that development in the child's use of visual media happens in a totally natural way without any form of adult assistance. It has even been suggested that adult influence can be damaging to children's creativity and should be avoided. Another belief about children's development and learning is that children neither start any self-learning nor play any significant role in the process. This is the notion that children are simply empty vessels which education will fill with knowledge. A variation of this is that children learn by just copying adults. Matthews (2003) holds that these views are both misleading and believes that child development involves an interaction between what unfolds in the child and what occurs within the environment. In the light of this, we should not overlook the special role that people have in providing those types of experiences, which foster and promote this development (Matthews, 2003: 21). Among the majority of drawing psychologists, art educationists and early years educationists there is an inclination to consider representation as a repeat presentation of prior experience. This idea is linked with a strong tendency to think of representation as synonymous with 'picturing'. Granted that representation does frequently try to make sense of previous experience, rather than being a copy, it is a dynamic, constructive act that actually shapes the experience itself (ibid: 24).

When a child is asked to draw an object, the child normally puts pencil to paper and produces an image of the requested object even if this is not in sight. Does the drawing represent an image held in the brain or does it stand for the object in nature? This is a main question that rises from a semiotic approach. In semiotics, a sign process starts with a 'material entity' that is present to an interpreter in a 'channel'. The channel might be given by a sensory modality, which for a child drawing could be looking at various forms of the object or pictures of it in various media. In semiotics, the perceived meaning carrier is known as the 'signifier', while the meaning arising from interpreting the signifier is known as the 'signified'.

Figure 3-2. Semiotic model of perception (Krampen, 1991)



(adapted from Krampen, 1991)

Peirce (1965) mentions three types of relationships between the sign and the object for which it stands, namely: iconic, indexical and symbolic. An *iconic* relationship occurs when the sign and the object have common properties such as in a portrait of a person. An *indexical* relationship is realised if a sign becomes a sign only in temporal or spatial contact with its object such as in a thermometer. A *symbolic* relationship between the sign and its object is arbitrary, based on convention and the user's learning (Krampen, 1991: 13).

In contrast to Krampen, both Peirce and Piaget do not distinguish between the material object external to the mind and the perceived object inside the mind (signifier). At the perceptual level (stage 1), the signifier comprises sense data constructed from different views of, or contacts with, the same object. The signified is the *fixed object* seen from its different perspectives. At the imaginary level (stage 2), the signifier is the symbolic representation of the mental image of the object. The signified is the internalized forgery of the perceptual activity required for understanding an object in its intricacy. At the conceptual level (stage 3), the signifier is the sign, or rather, the verbal or mathematical representation of objects or processes. The signified is the internal operation on symbolic objects aggregated in classes or as spatial systems. The 14 year old individual normally reaches the logical operations stage which means that he or she is capable of operating at all three levels: perception, imagination and conception (Krampen, 1991: 19).

What is the nature of imagination? How is environmental data processed in the mind? How is this data processed to issue in children's drawings? In science, the use of metaphors is widely used and one predominant metaphor is that environmental data are processed in the mind as pictures (Krampen, 1991: 22). The concept of mental image is central to Piaget's theory, but it has not gone without criticism. Krampen (1991) examined evidence for and against mental image as a mediator of actions including drawing and no convincing argument against iconic coding of the environment has been found. The image is an iconic coding mechanism the preserves important features of the environmental stimulus to mediate action.

3.3.2 Intellectual and Visual Realism

Luquet proposed the following five phases in drawing development:

1. Scribbling (ages 2-3)
2. Fortuitous realism (the discovery of similarities between certain features of scribbles and objects in reality; ages 3-4)
3. Failed realism (synthetic incapacity; age 4-5)
4. Intellectual realism (child draws what is known about reality; age 5-8)
5. Visual realism (child draws what is visible only from a certain point of view in reality i.e. a certain perspective; ages 8-12)

Following on from Luquet's work, Symington (1981) mentions three stages involved in the development of children's ability to produce pictures:

1. Scribbling: which an exercise for the child to gain facility with pencil or brush, with pictures bearing very little, if any, resemblance to the object.
2. Symbolism: where the picture is used more as a symbol of the child's idea of the object than to show what it is really like.
3. Visual realism: where the object and the picture bear a closer and more detailed resemblance.

Luquet's basic hypothesis is that in the development of children's drawings there is a tendency toward realism. Luquet introduced the phrase 'intellectual realism' which has subsequently been integrated into Piagetian terminology and which refers to a phase that precedes 'visual realism'. Intellectual realism is characterised by the child drawing what he knows and not what he sees. Firstly, the child has to shift from depicting what he knows of the present individual object. Secondly, he proceeds from representing this knowledge of the individual object to representing his visual perspective upon it. There is no evidence to show that these two phases are developmentally synchronous. Symington states that we should expect to encounter three distinct stages termed *symbolism* where the child draws what he knows of the genus, *intellectual realism* where the child draws what he knows about the individual and *visual realism* where the child draws the individual object as he sees it (Symington, 1981: 44-45).

In his theories on drawing, Piaget closely follows the work of Luquet. Piaget and Inhelder (1967) integrated Luquet's phases into their own schemes of children's drawing development and they describe three stages:

1. First Stage (I; up to the age of 4) also known as 'synthetic incapacity'. Here the child starts to embrace simple topological relationships in drawings.
2. Second Stage (II; 4-8 years) also known as 'intellectual realism'. This refers to the fact that children draw everything they know even if it is not visible.
3. Third Stage (III; 8-9 years) also known as 'visual realism'. This stage appears quite late because it entails the concept of projective and metric space that presumes advanced concrete mental operations. Drawings begin to amalgamate perspective, proportion and distance.

Later research has confirmed and provided evidence to support Luquet's claim that a shift occurs from intellectual to visual realism around the age of 7 to 8 years (Cox, 2005: 73). However, intellectual realism may coexist with rather than be replaced by visual realism, without an abrupt transition from one to the other. Further more, Luquet's observation that most people forsake intellectual in favour of visual realism by no means signifies that visual realism is superior since there is nothing wrong or childish about intellectual realism (ibid: 87).

Cox found that 3 to 4 year olds can recognise that real objects are not pictures; 6 to 8 year olds regard colour photos of the real objects, line drawings, drawings of abstract irregular shapes and complex abstract forms as pictures; while 9 to 10 year olds demonstrate a distinct change in child's judgement of drawings in the sense that realistic drawings of objects are regarded as pictures but not abstract or nonsense object drawings (Cox, 2005: 10). Intellectual realism can give us more information about the consistent structure and features of an object or scene, but the viewpoint may not be clear. Visual realism preserves the viewpoint and shows how the object appears from it, but this could be at the cost of losing some of the consistent features and distorting its structure. During mid-childhood, children increasingly concentrate on visual realism and become more successful in drawing from viewpoint (Cox, 2005: 73).

The idea of intellectual and visual realism influences many people's understanding of drawing development, but it is rather insufficient. A main reason is that it is practically impossible to separate 'seeing' from 'knowing'.

The child's presumed failure to capture view of the object (according to Piaget) is not the only reason that children do not produce visually realistic pictures. Studies have shown that children are aware of views and in some situations are able to draw these. Also, many children do not seem to move smoothly from one stage to another, but rather through a series of dynamic systems which gain information in means that cannot be accounted for by the major divisions falling between intellectual and visual realism (Matthews, 2003: 95).

Stages are not directly dependent on age, mental state, motivation, attitude of the community or any critical period of growth (Schaefer and Simmern cited in Gardner, 1980: 255). The procession is as follows:

1. Simple outlined figures; circles, squares or rectangles.
2. Figures ordered in terms of maximum contrast. Schematic figures stand for any member of their respective class.
3. Variability: objects become differentiated into parts e.g. schematic tree comes to bear a number of smaller branches. Figure becomes more vital.
4. Ability to organise a larger picture format, with more comprehensive and intricate balance.
5. Masters more specific features of representation, such as the use of shading and lighting and of colours. These late changes are affected by formal tutoring.

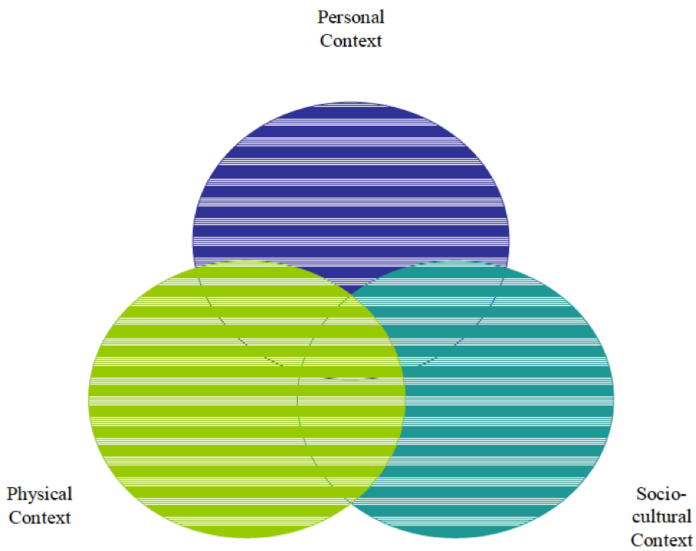
When students build a science representation they interpret their own construction, its coherence and adequacy in representing their intentions and ideas, and how much it will make sense to others (Waldrip et al., 2006: 88). It is disputable whether humans are predisposed towards creating and interpreting images in a particular way or if visual perception is learned and culturally variable (Wright, 2010: 71).

3.4 Towards a new theoretical model

I have considered a few major and well accepted interpretative models commonly encountered in science education and informal learning literature, namely: a) Contextual Learning Model (Falk and Dierking), b) Acuity Model (Patrick), c) Model Based Learning (Buckley and Boulter) and d) Activity

Theory (Leont'ev, Engeström). What follows is a basic description of a), b) and c) respectively, while d) is more extensively treated since it forms the basis of the interpretative model for dioramas (and other museum settings) I later propose in the discussion chapter 6. I consider Activity Theory more appropriate than the other theories, since it is more applicable to cultural tools and museum settings such as dioramas. The application of Activity System (that emerges from Activity Theory) is general. I believe its components can be adapted to the viewing, interpreting and understanding of dioramas.

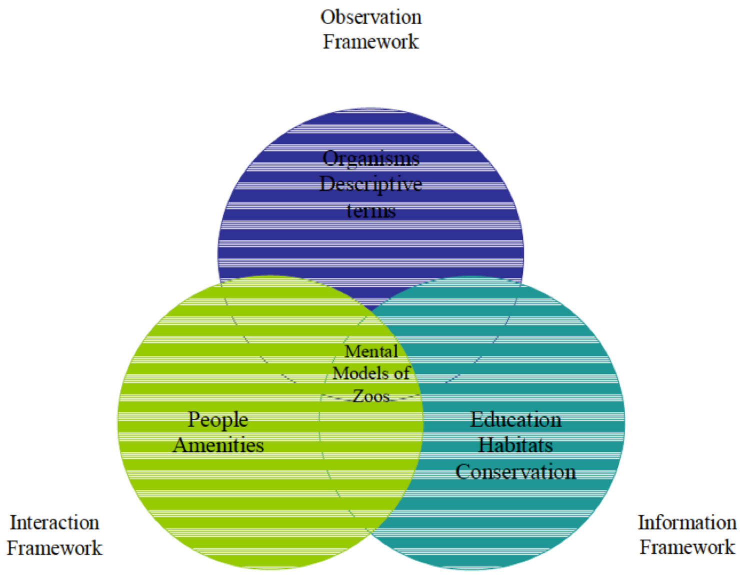
Figure 3-3. Contextual Model by Falk and Dierking.



The Contextual Model of Learning by Falk and Dierking (2000) explains that learning occurs via three main domains: the personal, sociocultural and physical. Learning is self-motivated, satisfying, and personally rewarding. Visitors are seen as a community of learners who socially share their knowledge before, during, and after a museum visit. People have a need to make sense of their environment by trying to recognize elements of an old context in the new context.

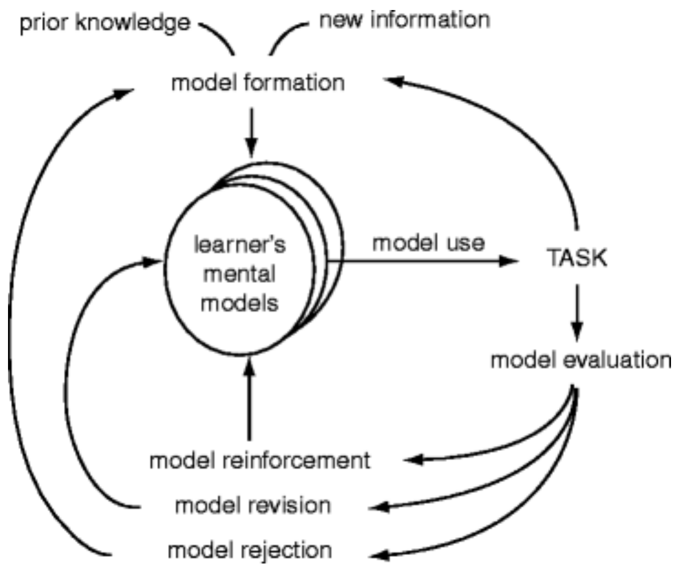
In the Personal Context, learning is facilitated by interest and 'new' knowledge is constructed from a foundation of prior experience. Interest arises from individual experiences and personal history. Apart from prior knowledge, appropriate motivation and a combination of personal, physical and mental action, learning also requires an appropriate context within which to express itself. In the Sociocultural Context, learning is a group experience as well as an individual. What and why someone learns is linked to the cultural and historic context of which they learn. In the Physical Context, learning is situated within a physical context. We need to make sense of the environment to find patterns and make order out of chaos, which is an innate quality of the brain. Spatial learning is integrated with all types of learning, while all learning is influenced by the awareness of place.

Figure 3-4. Acuity Model by Patrick.



The Acuity model by Patrick (2006) presents how the mental model of zoos is the synthesis of the Observation, Interaction and Information frameworks. Observation framework includes organism naming and words students use to describe animal care and animal behaviour that they saw at the zoo. The Information Framework includes the themes education, habitats and conservation. The Interaction Framework includes the themes people and amenities.

Figure 3-5. Model-Based Learning by Buckley and Boulter.



Model-based learning by Buckley and Boulter (2000) is the formation and subsequent development of mental models by a learner. Most often used in the context of dynamic phenomena, mental models organize information about how the components of systems interact to produce the dynamic phenomena. Mental models arise from the demands of some task that requires integration of multiple aspects and/or multiple levels of a system or situation. Model formation integrates prior knowledge and new information about the instance into a mental model of the situation. When the mental model is used to accomplish the task, it is evaluated for its utility in performing the task. If the mental model is deemed useful, it is reinforced and may become routinized with repeated use. If the mental model is deemed inadequate, it may be rejected and another model formed, or it may be revised and then used to try again. Revisions may involve making changes to an element of the model or it may take the form of elaboration – adding elements to the model in order to better accomplish the task. Elements may also be dynamic systems. Ideally, model-based learning results in rich, multilevel, interconnected mental models that are extensible and useful for understanding the world.

3.4.1 Activity Theory

The historical origins of Activity Theory can be traced back to the classical German philosophers Kant and Hegel, in the writings of Marx and Engels and in the Soviet Russian cultural-historical psychological of Vygotsky, Leont'ev and Luria (Engeström et al. 1999: 19). Although Activity Theory has its roots in Soviet philosophy and psychology of the 1930s, its central tenets have been subsequently taken up by researches around the world. It has been applied within a rich variety of domains, particularly in educational theory and human-computer interaction design. The influence of Activity Theory (and cultural-historical approaches to psychology) is evident in the writings of many currently prominent educational theorists including: Jerome Bruner, Michael Cole, Barbara Rogoff and Sylvia Scribner (Koschmann, 1998: 240).

Uncontroversial is that the emergence of the concept of activity pulled the Vygotskian approach towards the tradition of Marx's philosophical anthropology. Prominent ideas in Russian philosophical scene are:

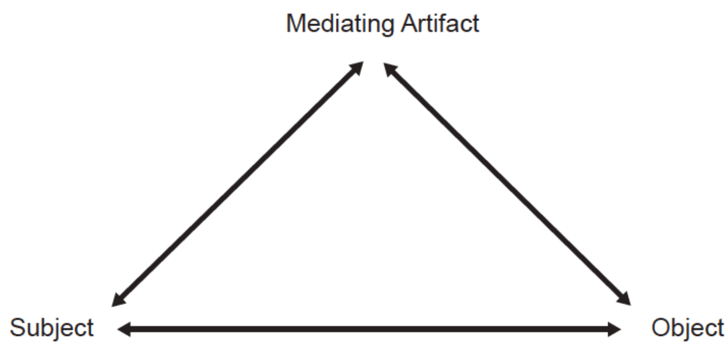
a) the *Social Self*: persons are essentially social beings; the very nature and possibility of our minds depends in some deep sense on our membership in a community or on our participation in culture.

b) the *Concept of Activity*: Russian thinkers were preoccupied with the claim that activity was a fundamental explanatory category in philosophy and psychology. The idea that we are essentially social beings is no longer an unfamiliar one in Anglo-American philosophy.

Bakhurst (2009) doubts if there is anything that warrants the name "activity theory" or even that there is any stable view of what the "activity approach" is or might be. The concept of activity was a vehicle for the articulation of a critical and creative species of Marxism. There are three principal generations of Activity Theory or Cultural – Historical Activity Theory (CHAT) as it is now often called:

1. First generation was inaugurated in the late 1920s by Lev Vygotsky, who is credited with having established a "triangular model" of action.

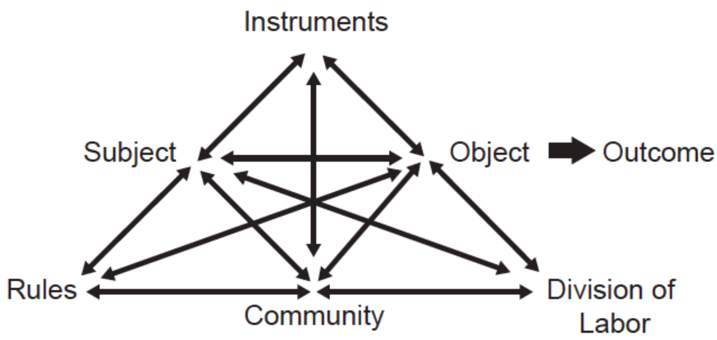
   Figure 3-6. Vygotsky's Tiangular Model.

2. The second generation is said to emerge on the basis of work done by Vygotsky's student, Alexei Leont'ev. The latter distinguished between

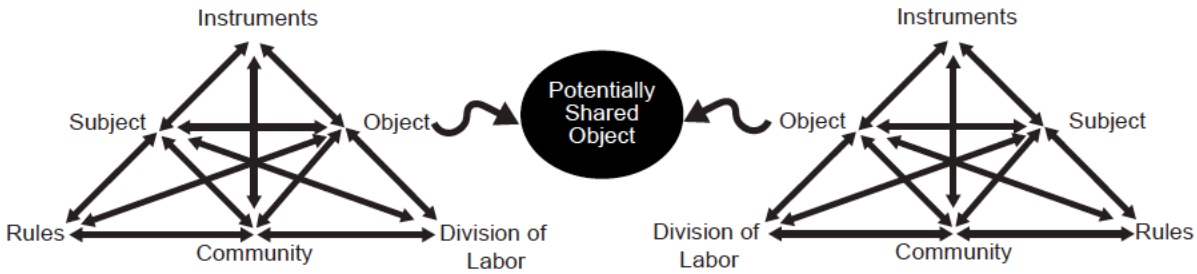
“action” and “activity”. An action is conducted buy an individual or group to fulfil some goal. In contrast, a community undertakes an activity and it has an object and motive. An action is individual, while the activity is collective.

Figure 3-7. Leont'ev's second generation model.



3. Engeström refers to what the diagram models as an “activity system” by taking up Leont’ev’s position and schematizes it.

Figure 3-8. Engeström's Activity System.



The idea is that the triangle can be applied to concrete subject matter. The terms used, such as “subject” or “object”, are given specific interpretation depending on the particular case under scrutiny. It is now common to speak of a third generation of AT that addresses issues such as representation, voice, emotion, identity and neglected by the founding troika: Vygotsky, Leont’ev and Luria.

Leont’ev’s work on Activity Theory has been criticised for an allegedly rigid and restrictive emphasis on tool-mediated production of objects as the prototypical form of activity. It is said that communication and mediation by signs are neglected or suppressed in this version of Activity Theory. Criticisms lead to a two-fold opposition: first mediation by sign is opposed to mediation by tools. Second, subject-subject relations are opposed to subject-object relations. Third, expressive or communicative action is opposed to instrumental or productive activity (Engeström et al. 1999: 21). It is ironic that at the same time that concept of object-related activity is criticised by some psychologists and philosophers for neglect of sign mediation, language and communication, some prominent linguists are finding the same concept of activity increasingly attractive as a means of conceptualising the interface between sociocultural and linguistic realms.

The concept of activity is the key concept that explains both the emergence of the world as a possible object of thought through the objectification of significance and the emergence of our mental powers, which consist in a certain mode of active engagement with reality and which develops in each individual (Ilyenkov, 1997). Bakhurst (2009) considers Ilyenkov's version as a purely philosophical argument that is not claiming to describe how minded beings actually evolved, but to explore the nature of kind and world in a way that outlines the limits of possibility. What philosophers of Anglo-American tradition see as a contingent circumstance of no philosophical importance, Ilyenkov places at the very center of the human condition: our active engagement with nature is the source of our humanity (Bakhurst, 2009: 205).

Engeström's depiction of the activity system identifies such elements as: subject, discourse, tools, rules, community, artefact, division of labour and object as separate, though related, components of the system. These elements cohere within the system in relation to the "object" that is contingent to it. But the elements of the system cannot belong entirely or solely to the system. Language is a major issue in relation to Engeströmian Activity Theory (EAT) and its ontology. In EAT, the ontological status of language is uncertain: is language one artefact among many? One key question in the ontology of activity in Engeström's triangulated account of the activity system concerns what it is that binds the components of the activity system together? It would seem to be the orientation towards a goal that provides an anchoring for the mobilization of the system. Given that, EAT aspires to be a "theory of everything", these questions carry considerable significance. The ontological problem of EAT can be further presented with reference to the "goal" as belonging somewhere outside the system, but at the same time adjacent to it and organizing it at the same time.

Engeström proposes six themes, presented in the form of a dichotomy or opposing standpoints that help us narrow down and define key dimensions of the very idea of activity as they emerge from literature. The themes are often the subject of heated discussions. The six dichotomies were condensed into three crucial questions:

1. What would be a viable way of modelling the structure and dynamic relations of an Activity System?
2. How can we incorporate historicity and developmental judgement into activity theoretical analysis, yet take fully into account the diversity and multiplicity inherent in human activities?
3. What kind of methodology is appropriate for activity theoretical research? Would it be one that can bridge the gaps between the basic and the applied and between conceptualisation and intervention?

Vygotsky formulated the idea of mediation, since he was very conscious of the revolutionary implications concerning control. He called the mediating artefact an auxiliary stimulus. The idea is that humans can control their own behaviour – not from the inside on the basis of biological urges, but from the outside using and creating artefacts. Activity Theory has the conceptual and methodological potential to be innovative in studies that help humans gain control over their own artefacts and thus over their future. Marx Wartofsky states that the artefact is to cultural evolution what the gene is to biological evolution.

Activity Theory today is transcending its own origins and becoming truly international and multidisciplinary. Although it is widening its acceptance, Activity Theory is not unproblematic. The theory deals with a tension between two developmental forces. One force pulls researchers towards individual applications and separate variations of general, often vague ideas. The other force, pulls researchers towards mutual learning, questioning and contesting each other's ideas and applications, making explicit claims about the theoretical core of the activity approach (Engeström et al. 1999: 20).

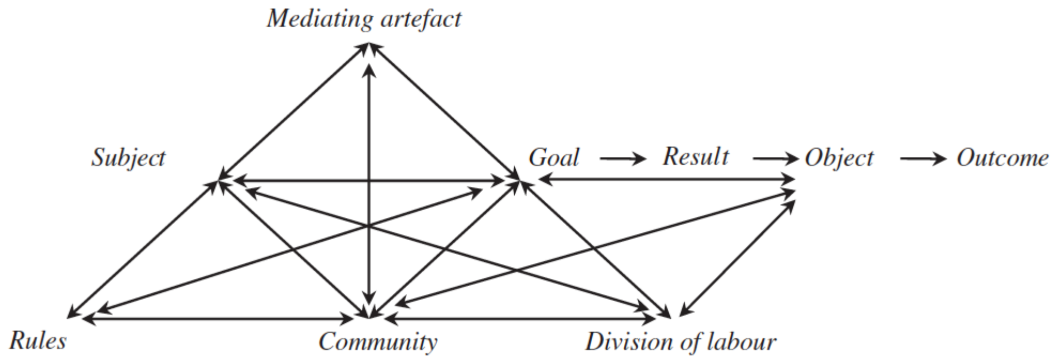
Cultural – Historical Activity Theory (CHAT) and Dewey's social constructivism share a common epistemological approach, stating that active individuals construct knowledge in social interaction using meditational knowledge. In CHAT, psychological and technical tools are the mediating artefacts between the individual and the world around him or her. In CHAT it is said that the artefacts human beings use influence their activity, while at the same time develop or create new artefacts that again affect their actions in new ways. In both CHAT and Dewey's social constructivism the person is looked upon as a conscious and active participant in the reciprocal activities that take place (Postholm, 2008: 38).

In CHAT, all higher mental functions are looked upon as having social or cultural origin. According to Dewey, the mind is developed in an environment, which is social as well as physical, and social aims and needs have been most potent in shaping it. In CHAT, tools or artefacts are more prominent than in Dewey's theory, as they are looked upon as extensions of the individual. In socio-cultural theory and later in CHAT, language is looked upon as the "tool of tools". Dewey believes that the ear is as much an organ of experience as the eye or hand. He furthermore claimed that social knowledge is learnt in social intercourse and that one also learns a great deal from others through this intercommunication.

CHAT connects the two concepts of internalization and externalization to learning. Learning is about how people use tools that exist in a given culture or society for thinking and acting (Wertsch, 1991). Internalization is related to reproduction of the culture; whereas externalization means processes that create new artefacts or new ways of using them (Engeström, 1999). Dewey's theory embraces these thoughts too. He held that learning takes place when young people and adults discover something new to them or as he put it, "when they experience the joy of intellectual constructivity and creativity".

The Activity System developed by Engeström (1999), based on CHAT, reveals the close connection between the acting subject and its context as shown in figure below.

Figure 3-9. Activity System from CHAT.



Mediating artefacts function as intermediary aids, which the acting subject chooses to use when trying to attain the goals for the actions. In Activity System context is not reduced to something that just surrounds it, but is knit in the actions, becoming a single process. The actions exist only in relation to the context that is visualized by the three triangles at the bottom of the Activity System (Postholm, 2008: 40).

Yrjo Engeström (1993) called Activity Theory "the best kept secret of academia". He was right in that in the Anglo-Saxon literature, Activity Theory was virtually unknown. Engeström's Activity Theory has been critiqued as being fundamentally static. Roth (2004) holds that such a characterization fails to recognize that the model is inherently dynamic due to two features: a) subject and object form a dialectic unit, which is the essence of an engine of change; b) human praxis and self-change coincide with change in life conditions, that is, the very notion of activity at the heart of Engeström's representation.

Much confusion arises from the fact that the subject is treated as coextensive with the physical boundaries of the individual or the group. But this cannot be, for the object of activity also includes its image, which is something perceived by and characteristic of the individual. As in any dialectical unit, there is an action-precipitating tension between the non-identical elements of the unit. The second idea of practical activity and learning as coinciding with changing life conditions can already be seen in Anglo-Saxon literature, without nevertheless attributing the idea to Marx and Engels. Practical actions do not just make nice artefacts, but bring changes in the entire system, including the identity of the subject.

Although the Engeström triangle depicts the structure of activity, it is inherently a dynamic structure, continuously undergoing change in its parts, in its relations, and as a whole. The triangle embodies the historical dimensions in terms of which human activity and all its various dimensions, including knowing and learning, have to be understood. If participation in activity changes the identity of the subject, what are the effects of alienating structures of schooling (such as confinement to chairs, mandatory silent activity, uniform)? If the two aspects of object (object of activity and object of thought) cannot be separated, what can educational testing, which divorces the subject from normally accessible tools, tell us about the competence of an individual across activities?

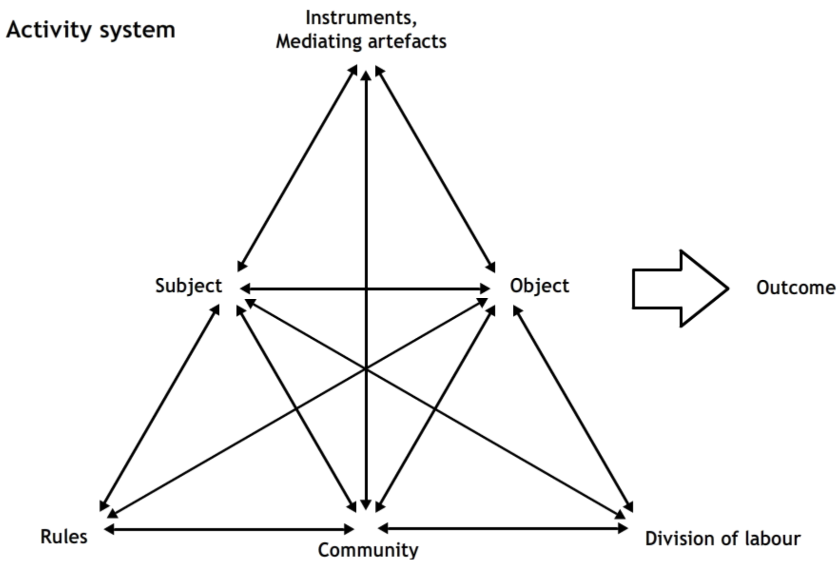
Participation in activity also produces and reproduces the very structure of the community, of which the individual is a constitutive part. For example, for individuals whose goals are aligned with the object and whose means of production, social relations and patterns of interactions (rules) coincide with the dominant culture of schooling, production leads to reproduction of bourgeois society. In schooling, and depending on the context, one can identify many contradictions beginning with out-of-field teaching, lack of tools (no supplies, books, technology for teaching), inappropriate preparation of teaching in difficult schools and culturally inappropriate pedagogies. Cultural-historical activity theory provides the tools to locate and articulate internal contradictions and to design concrete collective actions to remove them (Roth, 2004: 6).

Although activity theory is now less of a secret than it was 10 years ago, Roth senses that the potential of cultural-historical Activity Theory for research practice and practice research has not yet been realized. The study of human activity remains an area rich in interesting problems relative to the practical improvement of education and educational systems. Rather than accepting circumstances as they are, it encourages us to view each action also as transformational – changing the life conditions and ourselves. We do not have to accept activity system as they are right now, but continuously contribute to changing them.

Anglo-Saxon scholarship has appropriated Activity Theory in a particular way, grafted a dialectical theory onto a fundamentally dualistic epistemology. Such a move comes with a cost in the sense that important aspects no longer make sense in the new context. Perhaps there is a need to take on board more than some concept words and other titbits from Activity Theory – particularly the dialectical approach that is central to the work of the creators of Activity Theory – beginning with Marx and Engels, via Vygotsky and Leont'ev to Engeström. Many aspects that do not seem to make sense within a dualistic perspective (i.e. contradictions) that currently reigns in much of Western thought may well dissolve in the context of a dialectical approach (Roth, 2004: 7).

I consider the Activity System that originates from Activity Theory (Leont'ev and Engeström, 1999) as the most appropriate and adaptable in the case of interpreting a museum exhibit such as a habitat diorama. Based on this, I propose my own model, which I present in the last section of chapter 6, the Discussion. Figure 2-10 is an illustration of the components of the system and the interrelation between them. The section that follows the illustration of the Activity System explains what each component is meant to represent.

Figure 3-10. Activity System by Leont'ev.



- Object is the objective of the activity system. Object refers to the objectiveness of the reality; items are considered objective according to natural sciences, but also have social and cultural properties. In interpreting a museum exhibit this becomes the *focus* or the main theme of the exhibit.

- Subject is the actor or actors engaged in the activities. Likewise, the *subject* is the person interacting with the exhibit.
- Community is the social context; all actors involved in the activity system. For a museum exhibit this would be the *group* with whom the visitor is viewing the exhibit such as family or a class.
- Mediating artefacts (or concepts) used by actors in the system. Tools influence actor-structure interactions and they change with accumulating experience. Tools are influenced by culture, and their use is a way for the accumulation and transmission of social knowledge. The museum exhibit or diorama is the *artefact* that is conveying the message or the theme.
- Division of labour refers to social strata, hierarchical structure of activity, the division of activities among actors in the system. Not applicable to museum exhibit interpretation.
- Rules are the conventions, guidelines and rules regulating activities in the system. There are social norms and practices that apply to museums.

The Diorama Interpretation Model is derived from Activity System, which has been adapted to become applicable to museum exhibits with the inclusion of other features that are presented and extensively explained in chapter 6.

The following chapter 4 presents the methodology employed in this research. First a comprehensive treatment of a pilot study is given with conclusions and implications for the main study. Secondly, the design of the main study and data collected are explained as well as the application of the data analysis package Atlas.ti, followed by the progressional analysis of sets of drawings. The natural history dioramas studied in this thesis are presented and described.

4 Methodology

> *"In science a physical picture is often more important than the mathematics used to describe it."*
>
> Michio Kaku
>
> *Physics of the Impossible*

4.1 Drawing by children

Drawings are often the most striking creations that young school children are capable of. The empirical study of children's drawing dates back to the latter part of the nineteenth century, with a considerable volume of literature published during the last decade. Most studies were descriptive, but the developmental problem of children's drawings became evident and first attempts to formulate stages of development were seen. The first decade of the twentieth century saw the emergence of the ontogenetic variability of children's drawings. The second decade was marked by more work on developmental stages and systematic comparisons of various investigation methods. At this point in time, drawing development was solidly recognized as part of children's intellectual development. Eventually, this period saw drawings become the means of psychometric testing and pedagogical concern.

4.1.1 Children constructing drawings

Before Viennese art educator Frank Cizek (who worked with Gustav Klimt) children's art was not taken seriously. He promoted the idea that children's spontaneous artwork should be recognized as aesthetically pleasing in its own right and that adults should not interfere or tempt them into adult modes of representation. Nelson Goodman promoted the significance of children's access to and mastery of symbol systems embedded in the cultures of domains of knowledge. Gardner argues that educational systems are dominated by linguistic and mathematical intelligences, disregarding other abilities (Anning & Ring, 2004: 19). The following experts are among many who showed a grave concern to study the children's drawings: Rhoda Kellogg (1967); Rudolf Arnheim (1974); Howard Gardner (1978); Brent and Marjorie Wilson (1979); Judith Burton (1980); Christine Thompson (1990) and Paul Duncum (1993).

We tend to misunderstand children's art because we fail to recognize that the aptitude for creating art is innate, entirely self-taught in early childhood and only later is it redirected by adults who influence older children to copy the predominant art styles of the local culture. Unfortunately, few adults look at a child's work with serious concern for its aesthetic value. From the adult's conventional viewpoint, figures drawn by children appear primitive, incomplete and lack the photographic realism we expect of a drawing (Golomb, 2004). We ought to let children draw freely and teach themselves in art, while avoiding to present selected models to copy and never to pass unfavourable comments on their work. Art must always be motivated from within and never from the external (Kellogg, 1973: 9).

Arnheim (1969) acknowledged the enormity of the task for children of converting three-dimensional things into two-dimensional representations. As they struggle, they become dissatisfied with lower stages of differentiation in drawings and strive for more sophisticated versions. In his own words, all shape is semantic, that is, intrinsically meaningful and expressive of such qualities as roundness, sharpness, straightness, fragility, harmony and discord (Arnheim, 1974: 97). Representation rests on the invention of forms that are structurally or dynamically equivalent to the object. It does not aspire to "copy" the original, which would be impossible given the intrinsic differences between the properties of a two-dimensional and a three-dimensional medium. Drawing is an act of translation; it requires a radical transposition from the perception of a solid object extended in space to a representation that uses lines and dots on a two-dimensional surface.

Malchiodi (1998) sees drawing as a multi-dimensional activity i.e. a combination of the child's stage of development, individual experiences and feelings, and the socio-cultural influences and contexts in which they draw or paint. Power of visual narratives in communities has been quite strong throughout history and ranges from cave art in charcoal and soot to video art in digital media (Anning and Ring, 2004: 26). Existing models of drawing in comics, adverts, cartoons and computer games influence children in their graphic representations. In educational contexts, there is a strong urge to maintain a construct of the young child as innocent. Popular media driven graphics have long been considered as somehow corrupting to very young minds (Wilson and Wilson, 1977). It has been amply documented that children’s early drawings exhibit a creativity, which becomes negated by the conventionalized drawings of middle childhood (Davis and Gardner, 1992: 192).

Among the leading researchers in the field of children’s drawings we find Viktor Lowenfeld, Rhoda Kellogg and Jean Piaget. Lowenfeld's (1947) study was one that paved the way for the subsequent studies of children's art. He examined children's art in a consecutive way from birth till the age of seventeen years. He divided the children's art development into several stages as follows:

1. Scribbling Stage (from birth to 2 years approx.).
2. Manipulative Stage (2-4 years approx.).
3. Pre-Schematic or Symbol Making Stage (4-7 years approx.).
4. Schematic Stage (7-9 years approx.).
5. Drawing Realism Stage (9-11 years approx.).
6. Late Drawing Realism Stage (11-13 years approx.).
7. Adolescent Stage (13-18 years approx.).

Lowenfeld’ s model of artistic development also suggests that the personal growth of children is a naturally unfolding process that is constant and cannot be essentially changed (Freeman, 1997). Lowenfeld addresses in his developmental stages the topic of schemas in children‘s drawings. Freeman (1997) states that Lowenfeld describes schemas as symbolic forms that children make to represent many generic types of objects. Objects such as a person, tree, or flower, for example are popular schemas of children and can be observed in many of their drawings (Freeman, 1997). According to Lowenfeld (1987), schemas are stable concepts that remain constant and unchanging until a child requires another mode of representation (Freeman, 1997).

On the topic of colour in children‘s drawings, Lowenfeld (1987) states that there is often little relationship between the colours children select and the objects they attempt to represent and that the conventional use of colour (green grass or blue sky) may not appear in children‘s drawings until age eight (Schematic stage). Being critical of the use of colour or pointing out the correct or realistic colour for objects would interfere with a child‘s freedom of expression. Children’s use of colour is for colour’s sake in which the colour chosen is not for the purpose of imitating subject matter because they do not grasp an exact colour relationship (Lowenfeld & Brittain, 1987). Therefore, children's choice of colour may not be realistic in its imitation of their environment, but rather meaningful and expressive to the individual child.

Mendelowitz (1953) concluded a similar study for the children's drawings aged between 4-15 years. Betty Edwards (1979) defined the stages of the child art development into four main stages: Scribbling Stage (2.5-3.5 years), Formation of the Picture Stage (3.5-5 years), Complication Stage (5-10 years) and Realism Stage (10 years and over). Hurwitz and Day (1991) classified the developmental stages into three main stages: Manipulative Stage (2-5 years), the Symbol Making Stage (6-9 years) and Pre-adolescent Stage (10-13 years).

Rhoda Kellogg (1970) presented a four-stage classification following a large-scale study of drawings by children aged between two to four years. She discovered through her analysis that there were 20 categories of scribbles drawn by the children. Kellogg views these twenty basic scribbles as the building blocks of art and important because they permit a detailed and comprehensive description of the work of young children. She concluded that a child begins drawing the first line through the pencil and then he continues on his practices and attempts until he becomes able to produce a complete drawing. She summarized them into six main diagrams: the cross, the square, the circle (or oval), the triangle, areas of unique forms (odd form) and the diametrical cross (Kellogg, 1970). Golomb (2004) simplified Kellogg's model to two types of scribbles: loops and circles (generated by child's circular hand and arm movements), and parallel lines (generated by their horizontal, vertical or diagonal movements).

Artist and art educator John Matthews (2003) holds that all children's mark making is intentional and meaningful and defines three basic types of marks: vertical, horizontal arcs, and push-pull action. He refers to two modes of action: i) configurative modes that capture the shape and structure and ii) the dynamic modes that record the movement of events or objects often seen or imagined (Anning and Ring, 2004: 22).

Although Kellogg studied a large number of drawings, her research is unsystematic and may not clearly define the progressions and orders of complexity of the drawing development of individual children. Kellogg (1970) believed that there is a universal pattern of development in the drawings and art of young children. It is suggested by Kellogg (as cited in Thomas & Silk, 1990) that the simple forms and shapes that children make in their drawings can be found in the drawings of children from diverse cultural backgrounds. However, because of a possible lack of clarity in her analysis and system of data collection, the number of examples of children's art from primitive cultures in her collection is unknown (Thomas and Silk, 1990).

The popular vegetation images drawn by children are trees and flowers, in which Kellogg's classifications of Scribbles, Diagrams, Combines, Aggregates, Mandalas, Suns, and Radials are all evident. According to Kellogg (1970), flowers, trees, and transportation drawings (boats, cars, trains, airplanes) are not drawn in sizes found in nature or the external world, but in sizes needed to complete patterns or to achieve aesthetic goals. Kellogg (1970) believes that the child relies on the basic shapes of art and arranges them in relation to one another to pictorialize objects and scenes. Like Lowenfeld's model, Kellogg's theory of drawing development corresponds to the belief that children's growth and development cannot be changed, because it is a naturally unfolding process (Freeman, 1997).

Her work clearly showed that young children's art expressions are not very much learning from copying others, but are spontaneous products of the individual's own eye-hand-brain development and visual feedback from their own scribbles. She also states that arm, hand, eye and brain activity utilized in art has no age level start or end. Young children all over the world leave a record of scribbling movements in mud or sand or wet surfaces, which will be one or more of the twenty Basic Scribbles.

All human-made art originates from basic human capabilities common to the species, with varieties of art developing somewhat differently due to the individual's differing experiences in times and in places (Kellogg, 1973: 8).

Piaget used children's drawings only to support his own stage theory of child development (Kelly, 2004). Although Piaget occasionally utilized the drawings of young children to illustrate his theory, studies of drawings were never central in his theory development. Piaget proposed that children's drawings were essentially realistic in intention and that the child intended to produce a representation of an object in a recognizable and realistic fashion. The colour usage, shapes, and formation of lines used in the drawings and images of children can be attributed to an attempt to create a true representation of the real world, as opposed to an expressive interpretation (Thomas & Silk, 1990). As Piaget attributes the drawings of young children as a developmental process, it can be noted that it is a progression from stages determined by chronological age in addition to a child‘s ability to assimilate and accommodate to new stimuli in the real world. Although children's drawings were beneficial only to Piaget in sustaining his own theory of child development, his theory supports a succession of sequential stages, which contribute to the overall understanding of the child's intellectual growth and development.

Although each shares the belief in the importance of children's drawings in predicting the development of the child, Lowenfeld, Kellogg, and Piaget each have established models of analyzing the products of children with the intended purpose of determining the growth and progression of the child. Evident throughout each theory presented by Lowenfeld, Kellogg, and Piaget is their common perspective on a universal trend in the development of young children as seen through their drawings. Each theorist states that children develop in similar ways throughout the course of their young lives through experiences and chronological order.

Although each theorist may distinguish different possibilities for growth to occur, it can be concluded that the progression and images that children make are universal in outcome and product. Where Lowenfeld (1987) believes that children create drawings that are inherently important and reflect their desire to express their experiences and emotions, Piaget proposes that the drawings children make are the product of an intentional effort to represent realistic images (Thomas & Silk, 1990). Regardless of which theory proves this assumption, both theories consider the progression of a young child's drawing in migrating from the stage where this occurs to a stage characteristic of their continued growth.

Lowenfeld, Kellogg, and Piaget have influenced the field of education, art and child development through their distinct theories of children‘s drawings and development. Based on the literature in the field of child development through art as presented by Lowenfeld, Kellogg, and Piaget, assumptions made as to the outcomes of colour selection in the drawings of young children are as follows:

1. Kindergarten-age children will make expressive colour choices rather than logical colour choices in the drawings they create.
2. In relation to gender, girls would use more expressive colour choices than boys.
3. Logical colour choices would increase with age and higher level of academic ability.

The overarching concept in stage theories is that children’s drawings were seen as deficient as they worked towards the goal of visual realism. This construct of the purpose of drawing as portraying an accurate representation of objects, places and people is deeply rooted in the traditions of art training in Western culture. In other cultures, such as in African Art, Australian Aboriginal ‘dream time’ drawings and Islamic religious life, there is no such tyranny of representation as the highest goal of artistry (Anning & Ring, 2004: 18).

Arnheim states that representations tend to have the simplest visual form that will accurately capture the intended meaning, for instance, a circular contour to depict the perceived roundness of the human head. The meaning of a particular form depends on the alternatives that are available to the artist at the time or the extent to which his graphic vocabulary help him to make distinctions, for example the distinction between symmetrical and asymmetrical shapes. This leads to the concept of differentiation that refers to at least two outcomes: the addition of detail to an existent form that may enrich the structure, but does not affect the basic appearance, and modifications that lead to its transformation (Golomb, 2004).

Children all over the world scribble and no matter at what chronological age a child starts to scribble, he or she will go through basic developmental stages: *exploratory scribbling, disordered scribbling, controlled scribbling, shape stage, design stage* and *representational stage* (Garden, 1980; Kellogg, 1970; Lowenfeld, 1963, 1964; Striker, 2001). *Exploratory scribbling* describes the initial beginner scribbling through which the child is getting acquainted with the drawing tool and becomes interested in its properties rather than what it can do. These random marks on paper are usually a result of adult encouragement and an innate desire to imitate. Marks are usually light coloured in nature and basically the result of banging, dragging or sweeping the pencil or crayon on paper. These very first marks on paper are the child's means of communication, and similar to the first walking steps should be encouraged and praised. This is the child's beginning in literacy development.

Lines going back and forth or up and down resulting from shoulder rather than hand or arm movements, characterize *disordered scribbling*. Scribble patterns show the understanding of the paper boundaries. The child also starts to imitate marks other people make or choose to draw over someone's marks. Plenty of experience in making marks on paper as well as with finger paint is required to satisfy their needs. Parents' and teachers' comments should be descriptive and reflective instead of judgmental. *Controlled scribbling* is achieved when the child is pleased with his or her marks on paper and this motivates further mark making. The child now knows how to use the marker well to produce repeated movements on paper and energetic scribbling to create an overall shape. At the end of this stage, children would have gained sufficient muscle control to include in their scribbles all the twenty basic forms given by Rhoda Kellogg (1970) in her scribbling "alphabet". The latter aids in recognizing all the different strokes a child can produce.

Shape stage is an important milestone when the child begins to join two ends to enclose shapes that become circles, squares and triangles (at times filled with colour). Some children might also name their scribbles, seemingly wanting to connect the form they perceive on paper with what they know, example a circle is the 'sun'. Socially, the child at this stage wants to establish a link with others through drawing. According to Striker (2001), the use of lines and shapes as symbols for other things is the bridge leading to symbol recognition and formation employed in reading and writing. To Lowenfeld (1964), the naming of scribbling is of the highest significance since it shows that the child's thinking is changing from the kinaesthetic in terms of motions to the imaginative in terms of images. In the *Design stage*, the child shows greater understanding of symmetry and order in world around him or her, and starts to combine the learnt shapes. "Mandalas" (Sanskrit for magic circle), one of the most sacred forms in the world, appear at this stage. After age three, children are able to form suns with radiating lines (a natural scribble for all children) that adults perceive as the sun, but for the child it is first a perfectly balanced and orderly design. Deep exploration of mandalas, suns and radials lays the basis for drawing people and early animals.

Representational Stage is that when the child makes basic and general representations of people consisting of a round form, inner shapes that become the eyes and arms as two lines radiating from the circle. The basic human form is used to draw other objects like a car, a bug or a cat. The child draws just a "dog" rather than his or her dog. Later representations may include drawing more than one side, showing the interior of objects and setting objects into scenes. Representational drawing is the foundation for narrative and we can start by listening to the child's stories as he or she draws. Once children have established the pattern of drawing and storytelling, they may be encouraged to write down their stories.

Children will look for models when they need to achieve effects they have not gained in a natural way and which they are unable to create on their own. The model can serve as a way of helping the drawer achieve what he himself wants to express in a way that makes sense to him and to others. Gardner holds that if the child knows the object she would use an array of schemas possessed and produce a more artistic and less faithful picture. If the object were unknown, she would copy slavishly and try to produce a more faithful drawing (Gardner, 1980: 164). 5 to 8 year old children produce different drawings when they draw from imagination and when they copy an object. For example, children below eight years of age will draw a cup with a handle even if the handle is not visible

(Cox, 1992: 91). Brooks (2005) states that 'the power of drawing for children . . . is that it more closely represents thought' (pg.81).

Drawing Humans

The earliest shapes useful for the representation of any object and its parts tend to be circular. Straight lines may be added to differentiate and enrich in detail. The straight line serves two primary functions: it indicates extension and, when combined with the circular contour, it also represents a figural quality or "thingness", such as limbs, eyes, nose, mouth, eyebrows and hair. The circle and line create the sunburst pattern that is an early and highly favoured configuration comprised of a center or circle with lines or loops radiating from its circumference. The sunburst pattern can represent diverse objects such as eyes and eyelashes, hands, feet, suns, and flowers. The curiosity that leads to early (almost accidental) discoveries of figural features of shapes is motivated and is reminiscent of familiar objects and summons further experimentation (Golomb, 2004).

Drawing Animals

Whittaker and Golomb (cited in Golomb, 2004) asked 250 two- to seven-year olds to draw humans, plants and animals namely a cat, giraffe, fish, bird, snake and worm. They found that the four-year-olds showed greater competence and self-confidence drawing humans most frequently followed by birds, fish, giraffes and cats. Increasingly, the appearance of the real life object exerts its influence on the experimental. Cats are normally drawn in two-dimensional horizontal body displayed in side view, head in frontal view, four straight legs and an occasional tail. Most children draw fish and birds in side view although facial features continue to be drawn, frequently from a frontal view. Typically, a fish is drawn as an oval with the usual sideways fish-mouth, one or two eyes and a tail. Wings, beaks and aerial views graphically define birds, while the snakes become two-dimensional and often display a long wavelike and at times gracefully curved body suggestive of its motion. The developmental progression observed in four-year-olds becomes more pronounced in five- to seven-year-olds. Animals are now almost only drawn in their standard sideways orientation, highlighting the distinctive features of the subject. Four legged animal drawings attain some degree of figural differentiation and display the right-angular directions seen in humans. In birds, head, body, and tail tend to be aligned horizontally, while wings extend vertically. Similarly, the head and tail in fish constitute the horizontal direction, whereas gills and fins extend vertically. This shows that the principle of differentiation applies broadly, across a wide range of tasks and subject matter and that the animals drawn illustrate the same stages in the differentiation of shape.

A second principle that guides development is brought to focus, namely, the desire to create a likeness to the object. This desire to capture the object and represent it truthfully guides the direction the differentiation of form takes. The course of the differentiation of form is similar to an organismic emergence of functions and abilities. Apart from this, the second principle also needs to be considered, that is the orientation toward the reality of the object that codetermines the path of graphic development.

Drawing Plants

Similar to the graphic origins of humans and animals, the first representations of flowers and trees are also circular shapes. By ages five to seven years, the two-dimensional trunk has become the standard model. The crown is no longer drawn as a simple circle, but its contour assumes an undulating pattern whose dimensions tend to be wider than the tree trunk. Some of the drawings show branches, apples, and roots; increasingly, the trunk tends to be shaded and a darkened circle in its center suggests a hole, perhaps the home of an animal, or the place where a branch has been cut off.

Composition in Drawing

The creation of pictorial space depends on the coordination of several different frameworks that specify, a) the relations among the parts of a single object; b) the relations among several figures; and c) the relation of groups of figures to the superordinate structure that unites the different components into a coherent pictorial statement. The coordination of all the elements that comprise a drawing makes great demands on the cognitive planning capacities of the child. Golomb (2004) derives two dominant compositional tendencies from her data: the alignment principle and the centric symmetry tendency both being descriptive principles of organization. As children get older they appear to use the alignment principle of spatial organization with greater confidence. Figures tend to be placed at the bottom of the page, implying that the open space above now represents air or the sky with evident use of birds, clouds or the sun. Drawings gain in thematic complexity and there is a sharp increase in variety of forms, sizes, and colours, and more explicitly drawn spatial referents of ground and sky, which suggest that the figures belong together constituting a unit in nature or just in the drawing, example trees and flowers can convey the idea of a park. There is also a general tendency to place a single figure in the center, somewhere along the vertical midline of the page. This confers a degree of prominence and stability on the figure.

The dual compositional trends continue to dominate the drawings of older child ages seven to thirteen. With age, there is a noticeable increase in differentiation in the number and type of figure. Figures are grouped together to indicate a special relationship or a common interest, and such grouping is on the basis of similarity of size, colour, form, and activity (Golomb, 2004).

The task of drawing a garden is an example of a subject that lends itself to an alignment of items either on single or multiple levels, and that conveys its meaning almost independently of the arrangement of the depicted items. The drawing gains in aesthetic quality when symmetrical solutions are adopted. A coloured background unites the separately presented items. Grouping on the basis of the successful use of partial overlap can be an effective compositional tool that develops late and runs counter to the earlier tendency to give each object its optimal, unobstructed view.

Compositional development is a continuous process of revision, of monitoring the performance, planning actions, inspecting the outcome, deciding on its merits and flaws. This is a dialogue between what the eyes see, the mind constructs, and the hands create. Composition involves the organization of all the elements, of shape, line, size, colour, location, and direction into a coherent structure. The progression toward this aim is a slow though orderly process that begins with isolated object-centred descriptions, in which each object is depicted as an independent unit. Next, objects show some degree of interdependence, which is illustrated in the manner in which they affect each other.

4.1.2 Cultural influences on drawing

Unlike speech, image is displayed on a surface in framed space with all its features simultaneously present. One fundamental organizing principle and means for making meaning is the arrangement of the features in that space in relation to each other. In image, meaning is not just made by positioning of elements in space, but also by size, colour, line and shape. Societies have modal preferences and for a long time Western society has used writing in preference to image for most areas of formal public communication (Kress, 2010: 82).

> *"Perception (what we see), memory (what we choose to remember) and logical thinking (the sense we choose to attribute to things) differ culturally because they are cultural constructs (Hooper-Greenhill, 1999: 13).*

At times the sociological perspective of learning tends to be neglected and there is little regard for the socio-cultural milieu and its imprint that students bring with them to the learning situation (Gatt, 2005:1-4).

One way of looking at culture could be as a collection of shared experiences, beliefs, customs, and group values of people that inhabit it. Numerous different definitions of culture exist within academic circles, which differ from the common general public understanding of the word. Communicative sources, such as books, films, television program and exhibitions are cultural products created within their own sociocultural context. When people read and interact, their own experiences, emotions and values (mediated by their own social and cultural heritage) emerge. Meaningful learning occurs when the person is able to actively construct and obtain personal meaning in a situation. Practically all such learning is in some way socially mediated (Falk and Dierking, 2000: 39-41).

Influenced by Western culture, less variability and fewer idiosyncrasies mark older children's drawings as they try to resemble photos and try to capture as closely as possible the characteristics of objects. Children are increasingly inclined on getting things just right or looking at things just the way they happen to be (Gardner, 1980: 149). A main reason why children often draw the canonical view of objects, even if they actually see a different view, is that they are concerned to make the drawing look recognisable (Cox, 1992: 95).

Wilson and Wilson (cited in Krampen, 1991:34-35) studied the cultural influences on children's drawing of human figures in Egypt. They hypothesised that artistic images are changes of conventional constitutions shared by a group of artists. It was argued that children's drawings are not derived from their environment through imagination as suggested by Piaget's semiotic model, but from the stock of models and formulae present in the drawings of their peers. Drawing development will be restrained if this stock is limited, but it will proceed if it is substantial or if it can be augmented from sources such as books or media. Wilson and Wilson discovered that drawings of village children were different and less rich than those of city children, but there was evidence of a common Egyptian style.

This suggests that the anthropocentric pattern of generalization noted by Carey (1985) may depend on a relative lack of intimate experience with animals and plants. Rural children generalized more from wolf to other mammals than from humans to other mammals, a pattern consistent with humans being seen as atypical animals (Bang et al., 2007: 13868). But there were also two striking differences between the two rural populations. Rural European-American children of all ages showed asymmetries in reasoning between humans and animals and often justified a failure to extend a property from an animal to humans on the grounds that "people are not animals." In contrast, Menominee children of all ages showed no reliable human-animal asymmetries and were much less likely to say that people are not animals.

The Menominee creation story has people coming from the bear, and even the youngest children are familiar with the animal-based clan system. In short, there is an explicit cultural support for a symmetrical relation between humans and other animals. The second result observed was the reasoning strategy in terms of ecological relations. Ecological reasoning was a common strategy among even the youngest Menominee children. In contrast, such reasoning was only common among the oldest children coming from a rural culture. In summary, both culture and experience affect children's anthropocentrism and propensity for ecological reasoning (Bang et al., 2007: 13869).

Golomb refers to the notion of drawings as 'culture-free' works from the child's mind. However, comparisons between drawings from western societies and those from different regions of the world do not support a universally valid, culture-free instrument for cognitive assessment (Golomb, 2004: 343). After worldwide collections of children's drawings became available it was evident that there were marked differences in what children drew and how they drew it. While schooled children tend to draw conventional objects there is usually much more variety in drawing produced by unschooled children. It is well recognized that children draw the things that interest them and are important in their lives, but this varies in different cultures. Studies show that cultural child-rearing and teaching practice ideologies influence children's use of size-scaling, detail, placement and distance between objects. Choice and forms of content in children's drawings is influenced by the art traditions and values in the culture, the impact these have on child's art education, drawing models inherent within the culture and imported and the child's environment, lifestyle and nationality (cultural) values (Jolly, 2010: 248-71).

Cox reports similarities among cultures where young children prefer realism and colour, while older ones prefer complexity. Different cultures do exhibit varying drawing styles and it is clearly evident that there are alternatives to the western style of depiction. Children tend to conform to the style that predominates and is more valued in their own culture. For instance, the Warlpiri children of central Australia were found to be equally happy with western and traditional styles, since both are valued in their society (Cox, 2005: 239). Bedouin children in the Sinai peninsula draw women with the traditional Moslem garb and figures with very small or shaded facial area and lacking features. Cultural variability undoubtedly exists, but it comprises a limited set of variations on a common underlying structure, which is indicative of a set of rules that may yield alternative models, which are representatively equivalent (Golomb, 2004: 353). We are not likely to find a set of genes that predispose children and naïve adults to drawing tadpole type, open-trunk figures and right-angular relations. A fixed hereditary imprint would downplay the value that drawing as a record of visual thinking may have to the researcher.

When ask to mention plants, children in England were more likely to name Bryophytes and seedless vascular plants than children in the USA. This could be an indication that the local community plays an important part in what children know about plants. Children in both countries name agriculturally produced plants more than any other group and children mostly see these at home, in a garden or in a yard. Such differences seem to be culturally influenced (Patrick and Tunnicliffe, 2011: 638).

4.1.3 Drawing for eliciting knowledge

Drawing is an age-appropriate and non-threatening tool, which can provide a non-verbal means of communication and has the potential to allow children to express their experiences, thoughts, feelings and opinions (Brooks, 2005; Malchiodi, 1998 in Holliday, 2009: 252). A more recent approach (meaning-making) to analysing children's drawings, aims to appreciate how children make sense of the world around them through visual representations (Holliday et al., 2009: 248). In presenting his project to North American audiences, Mitchell (2006) was particularly struck by how often the drawings are received as a "natural form of expression" for children and an activity that "allows children to be children" (pg. 70).

The use of drawings as an evaluative tool is difficult since a complete understanding of the messages and the significance of children's drawings is lacking. It is still worth the attempt to use them to diagnose children's intellectual abilities particularly in informal settings where traditional evaluative methods are not very effective. It is interesting to see how children's drawings make explicit their beliefs and attitudes to everyday life. These attitudes are not free from stereotypes and simplifications that exist within the culture itself and so within the school (Moussouri, 1997: 41-46).

Most commonly used tests of understanding rely heavily on words. The balance between words and diagrams shifts between various probing techniques such as concept maps, interviews, fortune lines, relational diagrams and word associations. In drawings, the balance is shifted to one extreme, with very limited use of words restricted to the instructions and any that the students may choose to include into their drawings. Some modes may be more supportive of student learning than others, students can 'draw to learn' effectively, where the visual media affords 'specific advantages over the textual media' (Waldrip et al, 2006: 91).

Visual methods are said to be child-centered firstly in the sense that video, photography and drawing may be familiar, relatively non-intimidating and even enjoyable to the child. Second, visual methods are believed to offer a means of reducing the power imbalances that characterize interviews or focus groups in which children respond to questions posed by an adult researcher. Third, unlike verbal interviews or written surveys, visual methods do not give a "communicative advantage" to the adult researcher (Mitchell, 2006: 62). This shows that drawing is seen as appropriate for the cognitive and communicative skills associated with being a child, especially a pre-teen.

Though only one drawing item was included in the TIMSS science assessments, its inclusion demonstrates that drawing exercises can be used in large-scale, cross-cultural research (over 40 countries participated in TIMSS, with data collected in more than 30 languages) and be reliably scored (Haney et al. 2004: 248).

Apart from the word-diagram dimension, drawings also lie at the extreme of the degree to which students' responses are limited. Drawings are very open, with practically no limits on how the student may respond. In no way does this discount the value and utility of closed methods. It should be appreciated that both closed and open methods exist and that they trace different aspects of understanding (White and Gunstone, 1992: 98). The reason for drawings as a probe springs from their extreme positions on the word-diagram and closed-open dimensions. Interviews can also uncover understanding, but drawings expose it more efficiently and effectively and also with an openness that is more persuasive than could be possible through words. Drawings may bring out the drawer's feelings about the subject in a way that other probes cannot do. This has been shown in children's drawings showing scientists (White and Gunstone, 1992: 101). Drawings also expose stereotypes that effect representations people have of objects in plain sight, such as adding a stem to elm leaves that in reality do not have a stem (Symington et al., 1981: 48).

Drawings are not a substitute for children's voices and the absence or muting or fragmentation of children's talk about their images means researchers need to be particularly cautious about over-interpreting their images (Mitchell, 2006:69). The pleasure that children may experience during drawing is almost palpable and can be an important aspect of the analysis. Drawing activities were a non-stressful way for researchers and children to get to know one another (pg.70).

Drawings can be an alternative to verbal expression for children that are often able to express feelings and ideas that they cannot put into words (Lewis & Green in Bowker, 2007: 79; Gunstone and White, 1992: 101; Mavers, 2003). Drawings being the most open-ended of techniques may reveal unusual and unsuspected understanding. They may reveal hidden ideas that closed techniques couldn't since the respondents would be more confined to matching parts of their understandings to that of the prober. It would have been difficult for Symington and colleagues to discover the extent to which children's observations and images of leaves are affected by stereotypes had they not used drawings. Drawings have the potential of tapping understanding in a more holistic manner by allowing expression of attitudes or feelings together with cognition (Gunstone and White, 1992: 104).

> *The written recount implicitly poses the question: 'What were the salient events and actions and in what order did they occur?' The image with its spatial logic implicitly asks the question: 'What were the salient objects for you in that day and in what ordering do they have for me?' (Kress, 2010: 93).*

Most of the methods employed for gathering information on pupils' understanding of scientific phenomena rely mainly on speech and writing. Very few empirical studies have made use and evaluated the potential of drawings in elucidating scientific understanding. Children possess great capabilities in communicating through drawing that enable them to overcome language barriers (Mavers, 2003). Psychological research has a century-old tradition of using children's drawings, but other than that focused on art education drawings are rarely used in educational research. Drawing is normally learned informally as children interact with images they come across everyday, during experimentation and while observing others in action. Educational discourse does not place drawing on the same level to writing as a representation of learning. Teachers are not as willing to support children when drawing as they do with writing. Educationists and researchers can make sound decisions how to make good use of drawings for representation when they recognize the range of semiotic features in what children draw (Mavers, 2011: 126).

Though this research focuses on drawings, it is recommended to use drawings in concert with other methods of research and inquiry (Haney et al., 2004: 268). Various other methods such as essays may be used to document shifts in views, however drawings can do this very efficiently and effectively. Efficient in that they may be a very rich source of information in a single sheet of paper that requires little time to complete. Effective in that the person looking at them effortlessly assimilates them, particularly when the viewer is the drawer.

This is not to say that drawing is necessarily superior to other means, but it does have advantages. One is the relative ease of obtaining a rich mass of data that related to the children's mental models. Another is the international suitability of drawing that transcends the huge diversity of languages (Reiss et al, 2002: 59). However, finished drawings cannot portray the thinking, talking, social interaction and mark-making sequences that form a fundamental part of the process (Coates & Coates, 2006: 222). Drawings may also provide insights into children's cognitive, affective and social development (Bowker, 2007: 79). Unfortunately, schools tend to suffocate children's natural inclination to use drawing as a mode of thinking and learning. Many teachers consider drawing a minor communicative tool, secondary to writing and speech (Anning, 1997: 219).

How well can a drawing visualize a thought? An evident risk may seem the obvious limitation in the ability of a person to reproduce through a drawing what that person is really thinking about. Although there could be a limitation in the ability of a person to reproduce through a drawing what that person is really thinking about, the real purpose of the drawing was to express a message of meaning and it was this meaning that the analysis strives to unfold (Alerby, 2000: 218). Most children will draw when encourage to, but there will always be individuals who will find it hard to do so. Some will need to be assured that we are not after high quality artistic or design artefacts. Children and young people need to be told that it is not important how skilful they are at making drawings, but rather to use the drawing to visualize their thoughts (Alerby, 2000: 210).

In images it is neither possible nor necessary to represent all that is observed, known or remembered. The focus of instant interest directs the drawer to pick out 'criterial features' such as objects, people, scenes and events that are not normally shown in their entirety. Selection is not accidental or random, but very principled (Mavers, 2009: 266). In drawings, children record selective features that they find most relevant and in general connected with their personal experiences. Experiences include everyday observations of animals around them (pets, farm animals, local wild animals), media representations and narratives. Features vary greatly between children. Children's comments about their drawings show that the selected diorama features relate to former personal experiences and to present individual interests.

Drawing is by no means a problem free activity. According to Goodnow (1977) drawing comprises a problem-solving process for children, rather than a test of their knowledge. Drawings are not precise measurements of something as intangible as the implicit or explicit nature of the internal representation (Jolley, 2010: 178). Different forms may represent objects equally well if representation really deals with the creation of equivalences for objects and events. This could account for the wide range of individual variations that are observed in children's drawings.

> *"There are, however, distinct limits to the representational equivalences children create, and their drawings are constrained by their as yet limited exploration of the medium and of the objects they wish to portray" (Golomb, 2004: 360).*

It is crucial not to overlook the question of discrepancy between (cognitive) competence and (drawing) performance. Piaget and Inhelder (1967) have shown that there are performance problems associated with drawing. The implication here is that other, perhaps easier, tasks than drawing must be formulated and used if children's knowledge needs to be accessed. Any drawing is the result of its producer's active and creative reaction towards his or her experiences. However, we also need to consider children's growing control over visual resources and their feeling of confidence in the situation (Hopperstad, 2010: 432). This is an issue of primary importance to any research project that uses drawings as main data sources.

If drawing proves to be too daunting a task, the young person is likely to turn to other, less challenging means of communication.

> *"Unless one's own drawing can be viewed by oneself, and others, as reasonably competent, they are likely to be found distressingly wanting" (Gardner 1980: 262).*

It has been shown that drawings done by the same child of an animal from memory and others copied from a picture vary considerably in form and texture. When asked to draw any 'animal', the child retrieves a 'tried-and-true' schema from a repertoire of animal forms, one that may represent any type of vertebrate species. When copying, the child will try to faithfully reproduce the presented picture by following the outlines to yield a precise duplicate of the original. Studies by Wilson and Wilson suggest that the more one knows about the identity of something, the more likely one is to rely on previously elaborated schemas rather than on actual 'retinal' properties (Gardner, 1980: 164). Cox suggests that when researchers name the object, this conjures up or suggests a canonical view of the object, which will be drawn. On the other hand, when the object is not named it seems that it is less likely that the canonical view and more likely that a realistic picture will be drawn (Cox, 1992: 97).

According to Cox, our left-brain abilities tend to predominate which explains why most of us do not excel at drawing. We describe the scene to ourselves by naming and categorising what we know about the objects in it and this knowledge is often in conflict with the way the scene actually looks. In right brain mode, by contrast, we don't consider what the objects in the scene actually are, instead we look at their shapes and edges and at how these features relate to one another spatially to form the whole visual configuration. In R-mode, language-based descriptions of three-dimensional objects don't get in the way; we can have access to what we see much more. Children are not simply expressing themselves through drawing, but they are also novices who are learning how to draw (Cox, 1992: 193-213).

Caution is invoked in validity and reliability when interpreting children's drawings. Adults may misinterpret children's meanings, placing emphasis on features that were accidentally enlarged, colours that were inadvertently selected and so forth. We should not jump to conclusions about children's drawings, but we must ask them to tell us about them (Cox, 1992: 210; Holliday et al., 2009: 259; Haney et al, 2004: 268). Drawings are difficult to interpret without the child's verbal recall and the prober could well make incorrect inferences about the meaning that the drawer would have meant. It is known that children provide more information than they actually draw (Jolley, 2010: 238). For all probes, the sensitivity and precision of the assessment are significantly increased when they can be complemented with interviews. The prober may ask why the respondent drew anything in a particular way (Gunstone and White, 1992: 101-103). Drawings together with interviews can efficiently and effectively reveal what children have acquired from the exhibit through their mental model. Drawings have been found to be quite efficacious as memory aids for child recall. Twice as much information is recalled compared to interviews done without being asked to draw. Drawings aid in the recall of unique, interesting or emotional events up to a year after they occur. Consistent evidence also shows that they greatly improve recall for objects (Jolley, 2010: 235).

Children working in small groups can easily take a look, comment and ask questions about their colleagues' work. Children may make positive or critical remarks among them, but a critical remark may make a child give up the drawing and start all over again (Hopperstad, 2010: 448). To some children a rather open ended instruction ('Now I want you to draw something') may encourage them to pursue personal agendas and interests. Others may feel uncertain what to focus on and draw what they believe the teacher would expect and approve of (Anning and Ring, 2004). While some materials and activities (such as drawing, construction, role plays with puppets or dolls) may be familiar to children, children may find these boring in that they could use them on other occasions, both in the museums and in other contexts and would prefer some modern gadget such as a digital camera or video (Dockett, 2011: 19).

4.2 The pilot study

The pilot study would provide an initial experience and insight into the research. My aim was to use the study as a platform for the main research and to carry out any modifications to the research design after evaluating the limitations and shortcomings of the pilot. The findings were presented at two conferences and I also had the opportunity to deliver a presentation of the study to research colleagues at IOE who provided valuable feedback. Important changes envisaged for the main study are discussed in subsequent sections with the main research question being:

> *How do Maltese children visualise animals and plants in habitat dioramas through the lens of their previous knowledge?*

4.2.1 Methodology

The quantitative analytical method used scores of drawings using techniques based on the Personal Meaning Mapping (PMM) developed by John Falk and Lynn Dierking. PMM is a constructivist method that recognises the visitor as an active participant in constructing understanding of an exhibit and also in that it considers learners having unique experience and knowledge. Moreover, PMM is a method that does not seek a 'correct answer' from children to demonstrate learning (Bowker & Jasper, 2007: 139), but allows for the transformation of qualitative data into numerical codes that can be statistically analyzed by the researcher.

4.2.2 Research design

Two grade 5 classes (9-10 year olds) from two different schools, a state co-educational school (school A) in Rabat (central Malta) and an independent Roman Catholic school for boys (school B) in Valletta (south-east harbour), were chosen. School A has a student population of about 280 pupils, while school B has about 150 pupils in the primary school. In both cases, the pupils are mixed ability and coming from various social strata and do not pay for their education.

The study consisted of a three-task process, pre-visit measure, the intervention (visit at the Natural History Museum dioramas) and post-visit measure. Data collected during the pre- and post-visit measures consisted of drawings and recorded conversations during the intervention (school visit). The aim of the pre-visit drawing was to see what the children know about local flora and fauna. The aim of the post visit drawings was to see what captures the children's attention, how local animals and plants are visualized. Possibly the drawings could also show an increase in awareness of flora and fauna following the observation of the dioramas. Interviewing the children about their drawings would have appreciably helped in interpreting the content of the drawings produced. However, the limited time available did not permit this for the pilot.

4.3 Ethical Issues

Permission to access the classes was obtained from the Education Division (local authority) and the headmaster of the respective schools as well as the class teacher. An information leaflet with all relevant research details was sent to all parents requesting their consent. It was clearly stated that participation was entirely voluntary and formal written consent was obtained by means of a return cut-off. Parental permission and assent stems from the parents' rights to be involved in what occurs to their children and in that the level of competence of seven-eight year olds is rather doubtful. This remains a contentious issue with many authors arguing in favour of direct consent from children and that the competence of minors to consent to research is probably often underestimated (Lindsay, 2000: 12). Others argue that children feel compelled to consent given that most tasks and activities in school are compulsory (Morrow & Richards, 1996). Children, parents, teachers and school authorities were free to withdraw their participation from this study at all times.

The Institute of Education ethical procedure was duly completed in advance of the study. Names on drawings shown here or in any other document were covered to anonymise the work in recognition of the participants' entitlement to privacy and confidentiality as require by the Data Protection Act (2001).

4.4 Drawing data

4.4.1 Pre-visit task

The researcher is normally an outsider and not well acquainted with the children. Morrow and Richards (1996) expressed the point as follows:

> *'Children are not used to being asked their opinions and to relate their experiences to unknown adults, and probably need to have some familiarity with the researcher' (Morrow & Richards, 1996: 101).*

A week before carrying out the first task, I visited both schools where I introduced myself to pupils as a teacher and researcher and talked to the children about flora and fauna for a few minutes so that they could familiarise themselves with me before the visit. I explained what we would be doing and that we were going to visit the Natural History Museum that week. The following instructions were given to the pupils:

a. I would like you to draw a place with animals and plants that you see in Malta.
b. You are not being examined, but please try to work on your own without copying.
c. You can take your time, no need to hurry, but I think 30 minutes should be enough.
d. When you finish, please clearly write your name, age and class on the back of your drawing.

My interferences were minimal only answering questions to clarify the instructions given, otherwise the children were told that it was up to them what to include in the drawing. I assured them that I was only interested in animals and plants they would draw and not how well they could draw. I was present, together with the class teacher, for the duration of the task.

4.4.2 During the visit

Schools have been criticised for allowing visits to museums without sufficient preparation, focus and review (Tunnicliffe, Osborne and Lucas, 1997: 1053). All necessary logistic arrangements were made with the museum curator and the school senior management team.

At the Natural History Museum, I carried out the following activities:

1. A short briefing to pupils immediately prior to viewing the dioramas.
2. The class teachers lead the children into the diorama area in small groups of 2 or 3 pupils at a time, but were not staying with their pupils. Small manageable groups were chosen due to the small area in the diorama gallery to allow adequate observation and enable capture of conversations.
3. While children observed the dioramas, I audio recorded their conservations using an MP4 device (inconspicuous and easy to carry) and asked questions to clarify points and initiate the conversation with shy groups. A possible shortcoming is that questions may serve as cues that direct the children's attention onto a particular feature of the diorama, such as reference to a particular organism or physical feature in the diorama.

4.4.3 Post-visit task

After the visit, I again asked the children to produce a drawing which school A did in class on the visit day, while school B did the following day. I followed the same procedure for the pre-visit task, but now told the children that:

> *"I would like you to draw animals and plants that you saw in the dioramas".*

Pupils used HB pencil, pencil colours and plane A4 sheet paper in each case. I asked them to write their name, age and school on the back of the drawing. These were collected and analysed in relation to the ones drawn prior to the visit.

4.5 Analysis

The 9-10 year old 45 pupils involved in the study produced a total of 90 drawings, one pre- and one post-visit per pupil. Drawings were analysed qualitatively for biological content and also quantitatively through a scoring system adapted for this study. The scoring system was based on that developed by Bowker (2007: 82) from techniques used in the Personal Meaning Mapping (PMM) methodology of Falk & Dierking (2000). PMM was designed by Falk and his colleagues to assess how learning experiences affect the individual's meaning making process. This approach was designed specifically for use in free-choice learning environments and with the basic principle that no two visitors have the same visit experience. Each child's perception of a visit is not only influenced by the physical and social context but also by the personal context that the individual brings to the visit (Bowker & Jasper, 2007: 138).

The drawings were analysed on the following themes:

a) Animal diversity: reflects the number of different types of sub-ordinate animal categories represented in the drawings. A repeated category was counted only once. Categories were differentiated according to form.
b) Plant diversity: reflects the number of different types of sub-ordinate plant categories represented in the drawings. A repeated category was counted only once.
c) Artefacts and physical features: reflects human constructed structures, such as walls and pathways and the abiotic (non-living) aspects of the environment such as rocks, sand and water.
d) Diorama features: reflects animals and objects drawn and their arrangement as presented in a diorama that enable its identification.
e) Non-diorama features: reflects biotic and abiotic items not found in any of the dioramas viewed, as recalled from the child's memory.

The scoring method took into account the:

i) Occurrence: presence of the themes in the drawing.
ii) Variety: the quantity of different kinds of appropriate images for each theme included in a drawing. For example, in diversity, each type of category was counted as one point.
iii) Elaboration: the quality of the overall shape of the items drawn, such as detail of leaves, trunk and flowers, in plants or wings, legs and body plan in animals. The overall quality of the drawing was also assessed in terms of the different themes (as given above) included, link between items in the drawing e.g. bird on tree, and evidence of diorama representation

Table 4-1. Scale used for scoring elaboration (iii. above) based on Bowker (2007).

Score	1	2	3	4	5
Animals – accuracy of overall form and distinguishing features	very poor	poor	average	good	excellent
Plants – accuracy of general form, shape of leaves, trunk, colour, texture, etc	very poor	poor	average	good	excellent
Overall: general quality of the drawing	very poor	poor	average	good	excellent

i. Animal: recognizable outline and anatomical characteristics: bird-legs, wings, beaks, feathers; snail-shell, antennae, foot; rat-tail, elongated body, small feet, whiskers; hedgehog-pointed nose, spiky body cover.

ii. Plant: recognizable outline and features e.g. leaves, trunk, flower.

iii. Overall: variety of organisms, links between items in drawing, diorama features.

4.5.1 Qualitative considerations: pre-visit drawings

The children from School A drew mainly isolated animals of relatively large size that include a bird, snail, rabbit, bat, butterfly and hedgehog. The most recognisable animals were different species of birds, rabbit, butterfly, snails, rats hedgehog and bats, while the most accurately drawn were the birds, snails, and butterflies. Other recognisable animals were snakes and insects, with some pupils writing names next to some of the animals. Some children drew vampire-like bats. A third of the drawings showed evidence of some habitat features, but identifiable interactions between organisms were not clearly evident in any of the drawings.

Table 4-2. % pupils drawing the listed organisms in pre- and post- visit drawings.

	School A *(N=19)		School B *(N=26)		School A & B (N=45)	
Organism	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Bird	84% (16)	84% (16)	73% (19)	77% (20)	77% (35)	80% (36)
Rooster	11% (2)	47% (9)	4% (1)	15% (4)	7% (3)	29% (13)
Snail	84% (16)	47% (9)	31% (8)	23% (6)	53% (24)	33 (15)
Rat	26% (5)	21% (4)	0% (0)	0% (0)	11% (5)	9% (4)
Hedgehog	53% (10)	5% (1)	0% (0)	0% (0)	22% (10)	2% (1)
Bat	58% (11)	16% (3)	27% (7)	27% (7)	40% (18)	22% (10)
Rabbit	58% (11)	21% (4)	4% (1)	27% (7)	27% (12)	24% (11)
Starfish	5% (1)	16% (3)	4% (1)	23% (7)	4% (2)	22% (10)
Shells	0% (0)	37% (7)	0% (0)	19% (5)	0% (0)	27% (12)
Butterfly	53% (10)	53% (10)	8% (2)	12% (3)	27% (12)	29% (13)
Spider	0% (0)	16% (3)	0% (0)	0% (0)	0% (0)	7% (3)
Tree	32% (6)	42% (8)	19% (5)	8% (2)	24% (11)	22% (10)
Flower	5% (1)	53% (10)	4% (1)	8% (2)	4% (2)	27% (12)

*Presence of animal was noted only once even when it was represented twice or more times.

Trees were seen in 6 out of 19 drawings, while a flower was drawn just once. Human artefacts and physical features were rarely noted and the most recognisable features being door, window, rubble wall, rocks, soil, clouds and the sun.

The drawings done by children from School B had also isolated animals and only a fifth presented more than four animals. The animals frequently drawn from observation were a bird, a snail and a bat. A tree was included in 5 out of 26 drawings, while a flower was seen only once. Very few human artefacts and physical feature were drawn and noted in only a sixth of drawings. The animals, which were recognisable, were birds, rabbits, butterflies, snails, starfish, crabs and bats, with the most accurate representations being those of birds, snails and bats. Other recognisable types were reptiles; snakes, crocodiles, mammals; cat, cow and pig and birds. Twenty per cent of pupils wrote names near the animals they had drawn. A fifth of drawings showed habitat features, but no interactions between organisms could be documented.

4.5.2 Post-visit drawings

Following their visit, school A pupils produced drawings that presented a greater variety of animals, while the individual animals were more recognisable. Most pupils drew a sparrow, a butterfly, a rooster, a snail and other types of birds. Other animals drawn were shells, rabbits, rats, starfish, bats, spiders and hedgehogs. A greater percentage of pupils drew a tree and a flower with almost all (90%) drawings showing evidence of some form of habitat seen in the dioramas. Most drawings had an identifiable diorama setting seen at the museum with the most commonly represented being the rural courtyard (58%) and the sandy shore (47%). Children also drew the following abiotic structures window, boat, sand, rocks and soil.

The school B pupils used colour in their post-visit drawings, which improved the quality of the drawings and aiding in the identification of living and non-living features. The rationale for using colour was not investigated in this study. In this case too, children drew better recognisable animals and more variety in animal life too. Most pupils drew a bird while a third drew a rabbit, bat, snails and starfish. Less than 10% of pupils drew a tree or a flower. A fifth of the drawings showed a habitat feature from a diorama and a clear diorama setting. Recognisable diorama settings drawn were the beach, field and valley identified from the presence of a rubble wall, boat, sand, rocks, water and soil. Some non-diorama features seen were other animals, sun and unusual things like guns and syringes.

4.5.3 Quantitative Considerations

For the purposes of the quantitative analysis, a scoring rubric was devised to give the occurrence, variety and elaboration scores for each drawing.

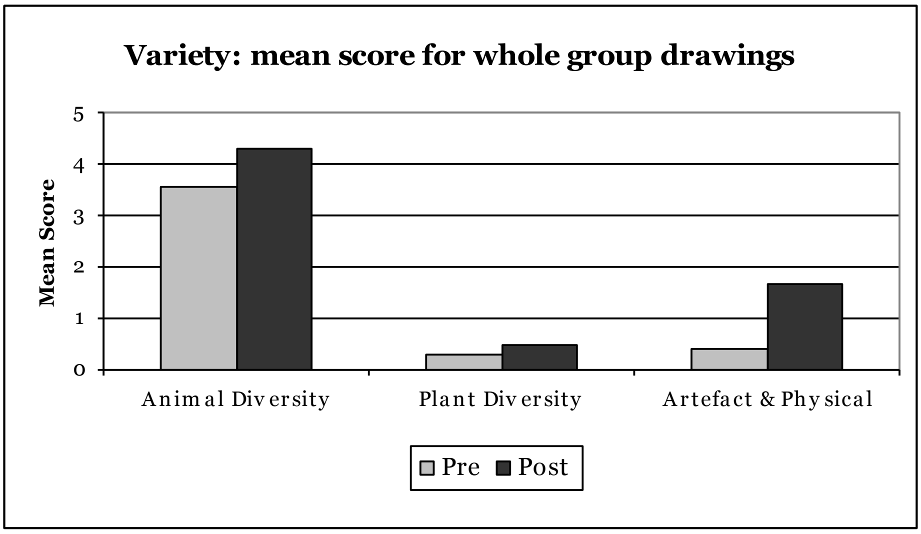
Table 4-3. Scoring Rubric **Name: Becky** **School: A**

Themes	**Occurrence**		**Variety**		**Elaboration**	
	Pre	Post	Pre	Post	Pre	Post
i) Animal diversity	Y	Y	6	6	3	4
ii) Plant diversity	Y	N	1	0	2	0
iii) Artefact & physical features	Y	Y	2	6	-	-
iv) Diorama features	N\A	Y	-	9	-	-
v) Non-diorama features	N\A	Y	-	5	-	-
vi) Overall quality	-	-	-	-	2	4

4.5.4 Variety scores

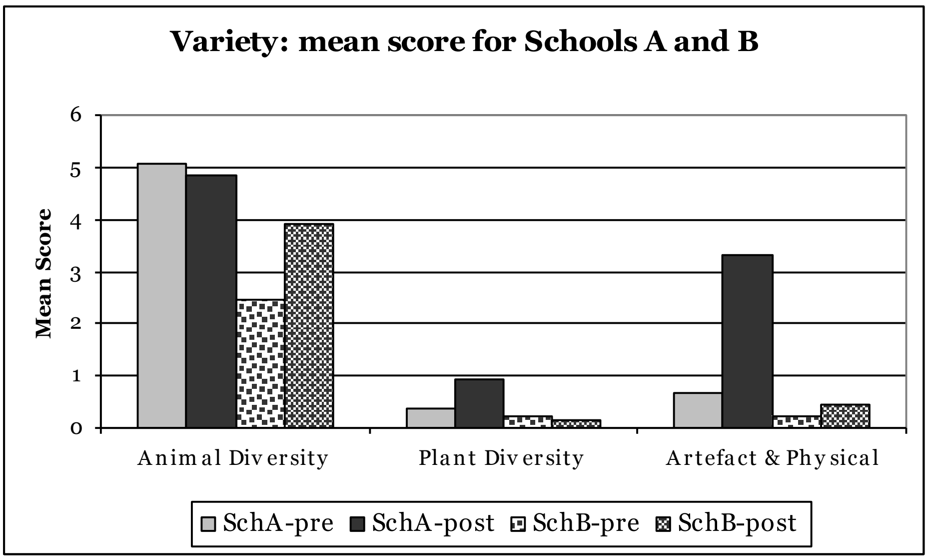
The mean scores for animal diversity do not show a significant increase in variety in post-visit drawings (t=1.69, >0.05) due mainly to a decrease in the score for School A pupils. There was a significant increase however, for school B (t=2.92, <0.05). School A pupils showed significantly more variety in pre-visit drawings compared to School B (t=6.09, <0.05). However, there was no significant difference between schools in the post-visit drawings (t=1.22, >0.05).

Figure 4-1. Mean score for whole group: variety (pilot).



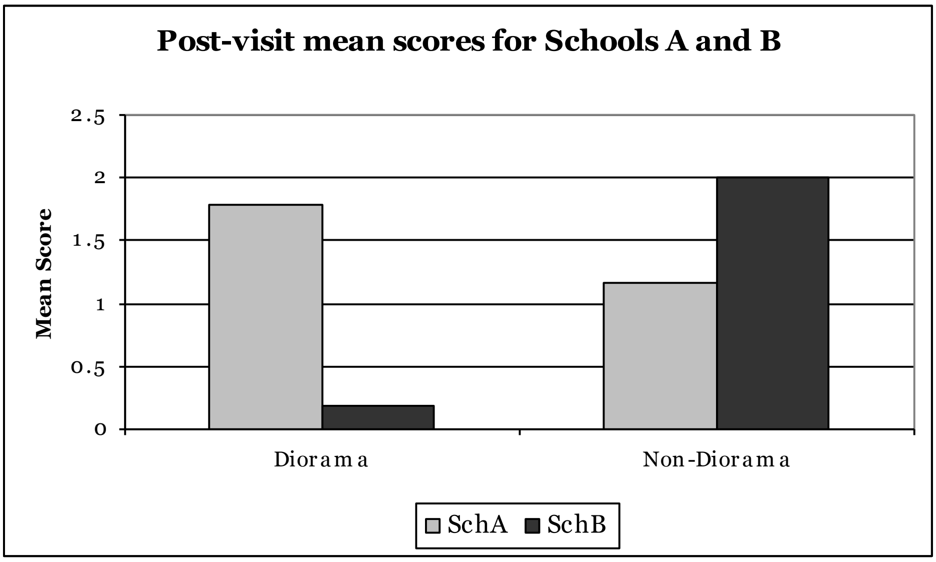
There was a significant increase in the artifacts and physical features in the post-visit drawings (t=4.40, <0.05) of the whole group, due in most part to a high score obtained by School A pupils. Moreover, there was a significant difference between the post-visit scores of both schools (t=6.99, <0.05).

Figure 4-2. Mean score for School A & B: variety (pilot).



There was a significant difference between the mean scores the two schools for the diorama (t=5.85, <0.05) and non-diorama features (t=2.21, <0.05) in the post-visit drawings. Obviously, pre-visit drawings did not contain diorama setting features since the pupils had never seen them before.

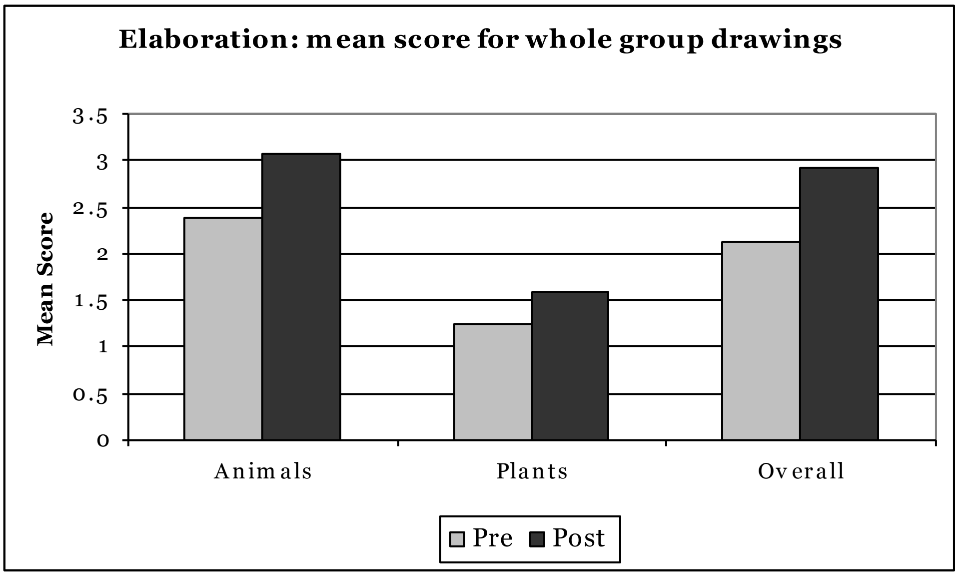
Figure 4-3. Post-visit mean scores for Schools A & B (pilot).



4.5.5 Elaboration Scores

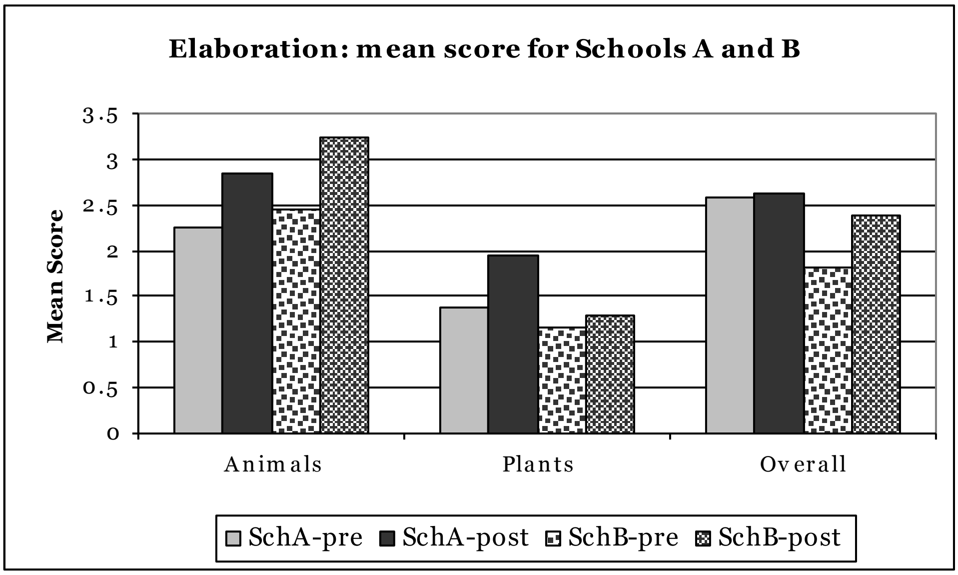
This refers to the overall quality of the drawings in terms of animals, plants and diorama features. There was a significant increase in scores from pre to post-visit drawings for the whole group. The increase was observed in the animal (t=5.63, <0.05), plant (t=2.71, <0.05) and overall categories (t=3.78, <0.05).

Figure 4-4. Mean score for whole group: elaboration (pilot).



Both schools A and B showed a significant increase in their post-visit scores for animals. School A had a significant increase in both the plants and overall scores but school B did not show any significant increase in either of these two categories.

Figure 4-5. Mean score for School A & B: elaboration (pilot).



4.6 Discussion of pilot data

This study focused on drawings and conversations as the primary data. Children were not interviewed on their drawing to elicit further knowledge and to add this to the drawings. They were only instructed to draw what they thought they would see in terms of animals and plants, and then to draw what they had actually seen after the visit.

The contents of the pre-visit drawings are an illustration of the children's prior knowledge that they acquired from school and other first hand experiences. Pupils from both schools drew, in most cases less than four, isolated and unconnected animals. Results are also consistent with children's aesthetic interest for nature being connected with the larger animals and specimens more often portrayed in the media such as mammals and the birds (Kellert, 1996). The fact that few pupils use knowledge relating to habitats where animals naturally occur is a result of the emphasis in primary level science teaching in Malta on naming and categorizing organisms as isolated entities (Tunnicliffe et al., 2008). Research has also shown that few pupils show an adequate integration of understanding of environments (Tunnicliffe & Reiss, 1999:146).

Very few pupils included any form of plant life, thus strengthening the view that plants are of no immediate importance to children (Bowker, 2007:91; Johnson, 2004:79). The majority of children drew birds and animals including snails, rabbits, bats, butterflies and hedgehogs, which were also the most accurately drawn.

The post-visit drawings showed that the pupil's awareness of flora and fauna had improved. Pupils produced drawings with a wider variety of more accurately drawn animals and more plant life. There was no significant difference in the animal variety between the pre- and post drawings. School B pupils showed enhanced awareness compared to those of school A, whose pupils evidently came to the visit with a more extensive prior knowledge. The dioramas objectively do not contain a large amount of plant life and pupils recorded little flora following the diorama observation. Nonetheless, more trees and flowers were noted in the post visit drawings meaning that, although not leaving a significant effect, the flora was observed by the pupils. A marked difference was noted in the ecological relationships. In the post-visit drawings, animals were drawn within an environmental context, as they were shown in the dioramas. This was the case for school A more so than school B where only 20% of the pupils showed any environmental context in their drawing. This finding could be partly explained by the fact that the School A pupils drew their second drawing on the day of the visit while those from School B drew the day following the visit.

Pupils drew the house yard, beach and field most often, an indication that these were the environments with which they were familiar more than the valley and fortifications. A most interesting aspect was how pupils placed animals in an ecological setting rather than presenting them as isolated objects. A significant increase in physical features is evidence of more environmental context in post-drawings. The School A pupils seem to have noted this and incorporated it into their mental model more so than the pupils of School B had observed and recorded.

Thus the data give an indication that, when allowed, children can reveal what they have observed and assimilated in their mental model through drawings

(Bowker, 2007:94). Evidence for this statement is from changes in number of different plants and animals drawn, the increase in environmental features included, and the better quality and richness of drawings. Drawing may be a very rich source of data and a useful tool for finding what children notice in museum exhibits, but not without limitations. Conversations recorded during the visits show that children observed a wider variety of animals than they actually drew. They mentioned animals in the dioramas, such as weasel, owl, grasshopper and chameleon, which they then did not include in their drawings. Data obtained from the conversations supports that from drawing in that the animals mentioned by the largest number of pupils match those that were drawn by the largest percentages of children. These include birds, butterflies, snails, rats, spider, bats, owls and lizards.

4.7 Conclusions from pilot

The time spent at the dioramas was to short to have resulted in any substantial impact on the children's learning. The museum lacks an organised and properly designed educational program, and the present dioramas are not designed and built with any such purpose in mind. Some form of well-focused, enjoyable and engaging workshops conducted by trained staff may help to encourage pre-visit activities in schools and to give the experience greater learning value. What we see, hear, taste, touch, smell and do gives us six main 'pathways to learning' (DfES, 2006). Therefore, museum exhibits should incorporate the opportunity for visitors to use all these senses.

Most children appeared to enjoy the museum experience and the drawing activity. Drawing on site would have been more appropriate but the museum does not offer appropriate space where this could have been done. Acoustically it was not always possible to capture all that the children were saying because they tend to speak together or do so in a low voice. Talking to the children about their drawing would be a helpful technique to enable researchers to better understand their representations.

Scoring of drawings provides semi-quantifiable data that help in the interpretation and analysis of children's learning (Bowker, 2007: 94). Perhaps one should not to rely too much on the conversion of the complex and rich data found in drawings to numbers. It is equally unwise to draw too many conclusions from such a short learning experience. Nonetheless, quantifiable data can be useful in strengthening the analysts' interpretations and conclusions about drawings and also revealing more about children's observations. Results from this study show that the viewing of natural settings does affect the children's perceptions and that these are, at least partly, incorporated in their mental models. Different children show this phenomenon to a varying degree within their drawings as revealed in the expressed models of their drawings. Habitat dioramas possess considerable potential as tools in the biological education of young school children and class teachers should be encouraged to exploit this potential.

4.8 Implications of the pilot for the main study

Due thought and consideration was given to the possible limitations of the pilot study. I was able to receive some constructive criticism on the methodology employed from reviewers, colleagues at conferences and at the Institute of education and my PhD supervisors. The following are the main modifications effected to the research design, which was then used for the main study:

a. The study was scaled up so that three classes of 9-10 year old boys and girls were now involved. The entire year 5 cohort of 63 pupils participated in the research that took place between November and December 2009. The school senior management team suggested that this would be the best period to carry out the study.
b. One main problem that was pointed out in the pilot was that the pre and post tasks were carried out in different contexts: for the class task the children were asked to draw a place with animals and plants in Malta, while for the museum task they were asked to draw animals and plants they observed in the diorama. Thus the pre and post drawings could not really be compared in a classical experimental design. Therefore, the design was modified in that sense that the comparative pre/post test analytical approach was abandoned, since this was evidently prone to serious issues of validity.
c. Instead, it was decided to use a pre-visit drawing as a measure of the children's prior knowledge and also to serve as an expression of their mental model of animals and plants in Malta. Prior knowledge effects new

knowledge obtained during the museum visit and so it was important to look into this aspect. There may also be specific cultural characteristics that Maltese children yield in their drawings of animals and plants that are interesting to investigate.

d. Students were now told that they could use colour in the drawing. They were given the following task instruction:

   "I would like you to draw a place with animals and plants in Malta".

   The linguistic of the instruction given has a major bearing on the responses obtained. Using the term 'wildlife' elicits different thoughts from using the terms 'animals and plants' in a local context. Through this question children were encouraged to produce drawings showing animals and plants and possibly in a habitat setting too.

e. Pupils were individually interviewed about the content of the drawing so that each pupil could clarify the content of the drawing produced. The pupils could also give their reasons for the choices made and what had influenced them in this.

f. At the museum children were instructed to draw before viewing the dioramas, similarly as they had done in class. They were also asked to produce a mind map with the central theme 'animals and plants' in which they could mention organisms that they might not have been able to draw.

g. After viewing, pupils were asked to draw their favourite diorama. This could not be done in the diorama area, which is far too confined a space.

4.9 The main study

An intricacy in measuring informal learning outcomes is the ability to assign the changes in learning to the actual treatment, if given, particularly if the study aims to measure changes over time. Does a child's knowledge about an animal link back to the classroom experience, the natural history museum, everyday life, or some combination of all of these? Is it possible to parse out where learning occurs? (Crane, 1994: 10). Pre-treatment, post treatment control group designs are widely used, but are vulnerable to a number of threats mainly associated with events, apart from the treatment, that occur in the time between pre- and post-field activities.

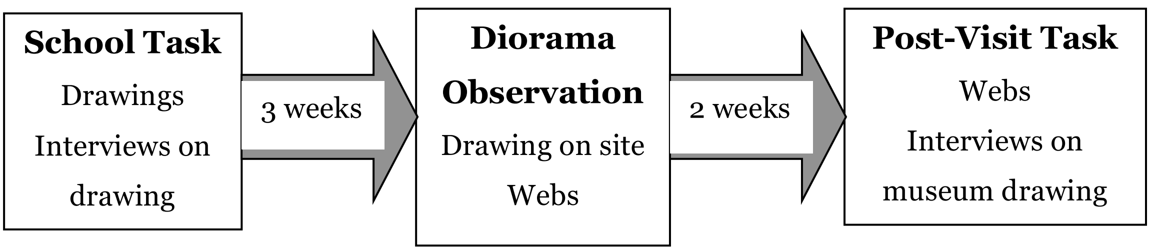
Relevant insights were also gained from the work of Falk and Dierking (2000, 2008), Hooper-Greenhill (1994, 1999), Moussouri (1997) on science understating and learning in museums, Kellert (1996) on aesthetic images of the natural world formed via formal and informal learning, Braund (2004) on out-of-school learning and science outside the laboratory, Anning (1997) on young children's learning from drawing Bowker (2007) on empirical and scoring methods in research with children learning in non-formal settings, and Reiss and Tunnicliffe (1999, 2001, 2007) learning from dioramas.

4.9.1 Research design

The research participant's chosen were three grade five classes of 9-10 year old from a state co-educational primary school in central Malta. The pupils were mixed ability and coming from the middle to working class social strata. The school has a solid history of positive academic performance with few pupils with severe social problems. There are three classes in each of the six scholastic years of primary education. Permission to access the school was obtained from the Education Division and the headmaster of the school as well as the class teachers. Ethical approval was also obtained from the Institute of Education Faculty Research Ethics Committee after reading through the procedures to be adopted and safeguards to be taken. Ethical issues associated with working with children are treated in a subsequent section.

This research project consisted of a three-task process; a pre-visit, the intervention (observation of the Natural History Museum dioramas) and post-visit task. Data collected during the pre-, museum and post-visit tasks consisted of drawings and personal meaning mapping (PMM).

Figure 4-6. Data collection time-line.



4.9.2 Creating webs (personal meaning mapping)

Diverse methodologies might disclose different perceptions and data collection methods can influence the type of perceptions identified (Bowker, 2004: 232). PMM is an approach developed by John Falk and his colleagues at the Institute of Learning Innovation in Annapolis (an organisation committed to understanding learning from a Constructivist-Relativist perspective in free-choice settings). The technique was created to address the five criteria for meaningful free-choice learning experiences (Adams et al, 2003: 18):

1. Emphasise validity over reliability
2. Allow for the visitors' agendas to emerge
3. Address the effect of time on learning
4. Respect that learning is situated and contextualised
5. Be open to a broad range of outcomes

Personal Meaning Mapping was designed specifically to use in free-choice learning settings such as museums. The use of the technique has disclosed a good deal about visitor learning from museums and has allowed a depth and breath of understanding of museum visitor experiences far beyond that provided by conventional methods. Museum staff and researchers remark that they found it hard to imagine gathering such rich data using any other methodology.

PMM was designed to measure how a specific viewing opportunity and possibly learning experience (visitors look identify and interpret but they do not necessarily learn) uniquely affects each individual's understanding or meaning-making process. It does not assume that every learner comes to the museum with the same knowledge and experience nor does it require that learners produce a specific "right" answer to be able to evidence learning. PMM focuses on the person's unique learning and not some prescribed outcome (Adams et al, 2003: 23). In this research the map is called webs since this is how the children know it.

PMM is a data collection method that involves asking participants to write down on a blank sheet of paper as many words, ideas, images, phrases or thoughts as come to mind related to a specific, word, phrase or even an image and this prior to viewing a museum exhibit or participating in a program. The 'prompting' word or phrase is placed at the center of the page and the related words, ideas, images or phrases are written around the central prompting word. Developing the prompt is a crucial part of using the PMM method. Participants are normally given as much time as they need or desire to write down all of their words, thoughts, phrases and ideas. When done, data collectors then encourage the participants to explain why they wrote what they did and to expand on their ideas. The expanded responses are recorded by the data collector on the same sheet of paper, using the visitors' own words and thought process. Finally, data collectors conduct an open-ended interview, probing any changes or improvements in their understanding shown by their responses.

4.10 Drawing data collected

4.10.1 Class task before the museum visit

Schools have been criticised for allowing visits lacking sufficient preparation, focus and review (Tunnicliffe et al., 1997). School preparatory work should include prior learning in other academic areas (apart from science) that could be concerned with the visit and knowledge and skills that are gained immediately before the visit (Tunnicliffe, 1999: 345). If the children have the opportunity to get acquainted with the researcher this would help to make them feel comfortable. Morrow and Richards (1996) expressed the point as follows:

> *'Children are not used to being asked their opinions and to relate their experiences to unknown adults, and probably need to have some familiarity with the researcher' (Morrow & Richards, 1996: 101).*

I introduced myself as a Biology teacher and researcher and talked to the children for a few minutes so that they could familiarise themselves with me. I explained what we would be doing that day, but did not tell them about the visit to the Natural History Museum in three weeks' time. The pupils sat in class and were asked to draw on blank A4 sheet of paper using coloured pencils. They were instructed to work individually, but they could see each other's work and some degree of crosstalk was difficult to avoid.

The pre-visit task was done in school (4th November 2009) as follows:

1. The task was done in class, where the children worked at their own bench.
2. I was present in class to give instructions and ensure all children followed them. I also supervised the children to ensure that everyone, as much as possible, worked independently.
3. Children were asked to produce one drawing. All instructions were given in native Maltese language with the main question being the following.

   In Maltese: "Jekk jghogobkom tistghu tpingu post go Malta fejn taraw annimali u pjanti".

   In English: *"Please, could you draw a place in Malta where you see animals and plants?"*

   a. You are not being examined, but please try to work on your own without looking at your colleagues work and copying.
   b. You can use a sheet of blank A4 paper, pencil and colours.
   c. No need to hurry, take your time, but I think 30 minutes should be enough for you to complete your drawing.
   d. When you finish, please clearly write your name, age and class on the back of your drawing.
4. Children were allowed to draw freely on blank white A4 paper using HB and coloured pencils or crayons only. As instructed, each child worked individually, quietly and with minimal communication with the child sitting next to them.
5. I went round the benches, supervising the task without intervening but to answer any questions. The task lasted between 25 to 30 minutes. Just before collection, children were asked to write their name, age and class on the backside of the drawing.
6. After collection, I moved to a quiet room, called each child and individually asked them about their drawings.
   a. What is the drawing showing?
   b. Did you draw any animals? Could you indicate and mention them?
   c. Did you draw any plants? Could you indicate and mention them?
   d. Apart from animals and plants, what else did you draw?
   e. Why did you choose to draw this picture?
   f. From where did you get ideas to produce your drawing?
   g. Do you want to add anything else before you go?

7. I recorded answers into an information sheet (see appendix) for each drawing per pupil.
8. I also audio recorded the structured interviews to that I could review each and update the information sheet definitively.

The pupils were assured that I was only interested in the items they would draw and not how well they could draw. It is important to assure people that the exercise is not a "test" of their drawing skill, but rather an alternative way of documenting and making visible their thinking and feelings about the focus of the drawing exercise (Haney et al, 2004: 269).

4.10.2 During the visit

People construct meaning as they view exhibits of animals, plants, minerals or artefacts during field trips in science museums, botanical gardens or zoos and any specimens found in various other places (Bruner *et al.* in Tunnicliffe 2005). Tomkins and Tunnicliffe (2001) highlight the relevance of the 'universal activity' of observation to science education research and that there are gains to be acquired from the study of children's spontaneous expressions.

Three weeks (postponed by a week due to a power failure) after the class task, students visited the Natural History Museum to view the local habitat dioramas. The class teacher, teacher assistant and the researcher (i.e. myself) accompanied the children to the museum, where the curator greeted the group. At the museum, the class teacher and assistant supervised the children, while I conducted the research. The drawing tasks were done in the larger bird hall, which leads to the adjoining but much smaller diorama room. The three classes arrived at the museum in turns, an hour apart from each other. The space available was adequate for a class of 20 pupils to work comfortably with minimal disruptions and was easier to control.

The visit comprised the following activities:

1. Before viewing the dioramas, children were again asked to produce a drawing. As for the class task, they were asked the same question:
   "Please, could you draw a place where you see animals and plants in Malta?"

The diorama room was too small to accommodate between 18 and 20 pupils drawing on the floor. So the children drew in the more spacious bird hall, on floor mats, using A4 paper and pencil colours. They worked in small groups near each other, so they were supervised to ensure that each child worked individually.

2. After they were asked to construct a mind map (they call it a 'web') based on the main theme 'animals and plants' seen locally.
3. With the help of teachers the children entered the diorama area in groups of four and observed each of the five dioramas always in the same order. They were asked to look carefully and discover as many animals and plants as they could. I was careful not to intervene or lead the children unduly to avoid influencing their thoughts and so diminish the validity of the data collected. I just stood at the side and observed, allowing the children to freely interact with the dioramas.
4. After the diorama observation all pupils were given boards to produce another drawing of their 'favourite' diorama. This drawing was done in a hall just outside the diorama area and they had 10 to 15 minutes to complete the drawing.
5. Children were asked to write their name, age and class on the back of the drawing before they handed it in.
6. They were also asked if they wished to add anything to or modify their mind map in the conclusion of the task, before leaving the bird hall.
7. The conversations by the children while observing the dioramas were audio recorded. A detailed discourse analysis was not being envisaged, but rather the capture of any relevant comments or behavioural insights.

4.10.3 Post-visit task

1. A fortnight following the visit, each pupil was individually interviewed about the two drawings produced in the museum. Interviews were conducted in a quiet room at the school and audio recorded. The following questions were asked:
   a. What is the drawing showing? (pre-diorama)
   b. Which diorama is the drawing showing? (post-diorama)
   c. Did you draw any animals? Could you indicate and mention them?
   d. Did you draw any plants? Could you indicate and mention them?
   e. Apart from animals and plants, what else did you draw?

   f. Why did you choose to draw this picture?
   g. Why did you choose to draw this diorama?
   h. From where did you get ideas to produce your drawing?
   i. Do you want to add anything else before you go?
2. During the interview, children were asked if they wanted to add anything to their webs.

The purpose of classroom and pre-diorama viewing activities was to probe the children's familiarity with and knowledge of local animals and plants before visiting the museum. The purpose of the drawings done before viewing the dioramas was to determine whether the novelty of the museum visit would produce any significant differences in drawing to that done in class. The novel museum context and the specimen exhibits at the museum would be expected to influence to a certain degree their expression of mental models i.e. the conceptual lens through which the dioramas would be observed and interpreted.

4.10.4 Data collection and scoring

The data collection in this study was done by means of drawing, unstructured interviews, webs (PMM), observations and audio recordings. The main and most important data source are the drawings, with a thorough content analysis of all drawings. Other methods such as questionnaires and structured interviews could have been, but were not used.

Gunstone and White (1992) have reservations on reducing a complex entity such as understanding to numbers. Drawings could be scored for quantity of change in a desired direction from before any form of treatment to after, but this would be subjective. They hold that 'reducing rich data of drawing to a score destroys information' (Gunstone and White, 1992: 105). It is difficult to establish rules for scoring, since drawing can be employed to test understanding of a huge range of ideas and for a variety of purposes. It is likewise complicated in most applications to lay down prior criteria for understanding that a drawing should show. The problem of creating a reliable scoring procedure stems from the openness of the drawing technique.

4.11 The Maltese natural history dioramas

In outlining the educational rationale behind the dioramas, the curator of the museum stated that the settings were meant for visitors of all ages. One aim was to offer a showcase of what some typical Maltese habitats have to offer including an exemplar of the animals and plants that could be encountered in such habitats. Another aim was to offer an opportunity for free choice observation of unique museum exhibits representing flora and fauna in local habitats. A third aim was to create conservational awareness and environmental responsibility. His intention was to present an example of a negative human effect on the environment. These aims guided the way the research was carried out and which activities were done. Data collected and analyzed shows how far the exhibits have influenced the children's thinking and visualization of local flora and fauna in Malta.

At the Natural History Museum of Malta there are five small habitat dioramas housed in a narrow room, poorly illuminated and only allows for a handful of visitors at any one time.

The figures 4-7 to 4-11, which follow show the five habitat dioramas at the Natural History Museum at Malta with the animals and plants present listed below each illustration.

Figure 4-7. House Yard habitat diorama.

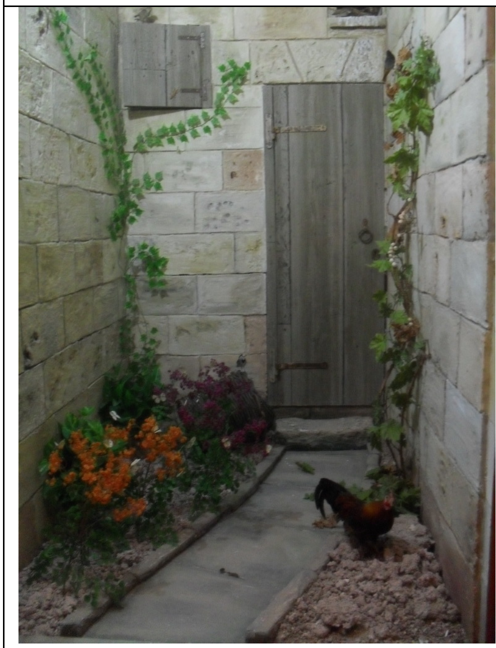
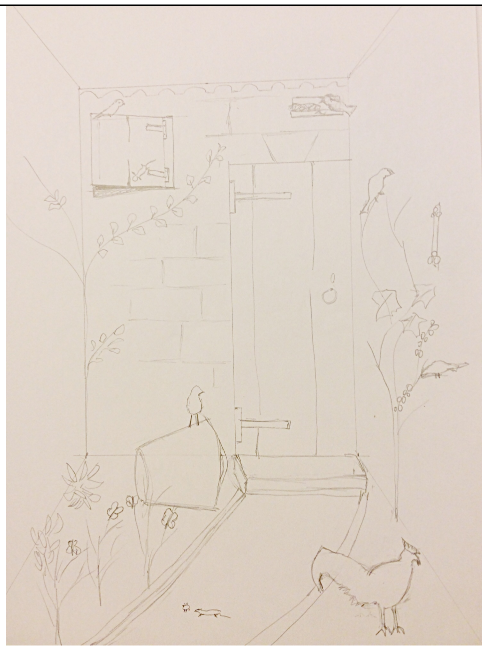
House Yard	Representation (my sketch)
	
Animals: Cockerel Shrew Cabbage butterflies (on flowers) Snails on twigs Snails on wall Bird on right hand side twig Bird and nest in ventilator Bird on window shutter Bird on cane basket Gecko on window shutter Spider and web Beetle in pathway	Plants: Vine tree Creeper 2 Types of flower (x 2,2) 2 Types of succulents (x 1,1)

Figure 4-8. Agrifield Habitat Diorama.

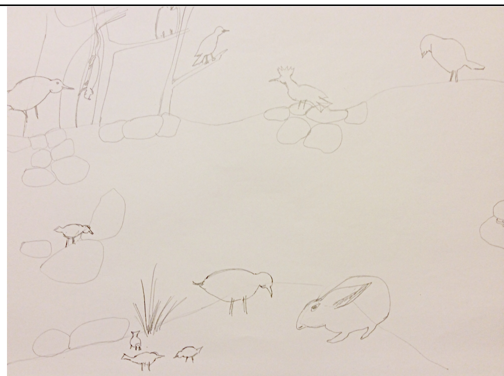
Agrifield	Representation
	
Animals: Wild rabbit, skink, wasp hive On soil: yellow wagtails (x3) and curlew sandpiper. On rubble wall: sparrow, hoopoe and corn bunting. On trees: bee-eater, golden oriole, cuckoo & turtle dove. Mediterranean chameleon.	Plants: Trees (x3) Grass Capers in rubble wall (x5)

Figure 4-9. Valley Floor Habitat Diorama.

Valley Floor	Representation
	
Animals: Brown rat (x2), painted frog (x3) Numerous *Helix aspersa* Numerous other snails species of smaller sizes and pointed shapes Eight species of birds, one of which is in flight.	Plants: Common reed

Figure 4-10. Sand Dune Habitat Diorama.

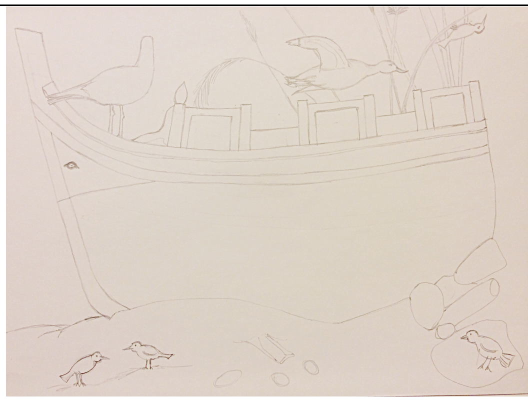
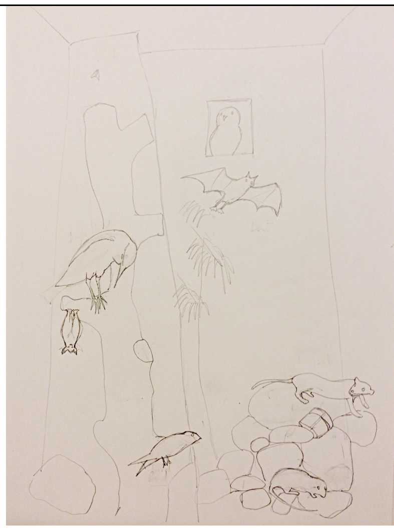
Sand Dune	Representation
	
Animals: Little ringed plover (x2) on sand. Spotted Redshank on rock (r.h.s). Sea gull on front of boat. Mallard flying. Bird resting on twig behind boat. Dead sea urchin shells. Squid endoskeleton (x2). Swordfish vertebrae. Bivalve shells.	Plants: Mediterranean Thyme. Cane.

Figure 4-11. Bastion Habitat Diorama.

Bastion	Representation
	
Animals: Weasel on rock (on floor). Brown rat on rock (on floor). Bat flying, bat resting on tree trunk. Night Heron and Starling on tree trunk. Barn owl in bastion window. Spurge Hawk moth on bastion.	Plants: Trunk with no leaves. Eucalyptus tree. Caper shrub (x2).

4.12 Data analysis using Altas.ti

ATLAS.ti is based on the NCT (Noticing, Collecting, Thinking) model of qualitative data analysis, where the three basic components are noticing things, collecting and thinking about things (Friese, 2012: 92). It is a powerful workbench for the qualitative analysis of large bodies of textual, graphical, audio, and video data. The content or subject matter of these materials is in no way limited to any one particular field of scientific or scholarly investigation. Its emphasis is on qualitative analysis, however Atlas.ti also permits semi-quantitative data analysis. The package deals with "knowledge management," which emphasizes the transformation of data into useful knowledge. ATLAS.ti was originally designed for the social sciences, but it has been employed in areas that were not anticipated such as psychology, literature, medicine, software engineering, quality control, criminology, administration, text linguistics, stylistics, knowledge elicitation, history, geography, theology, and law (Friese, 2012: 11).

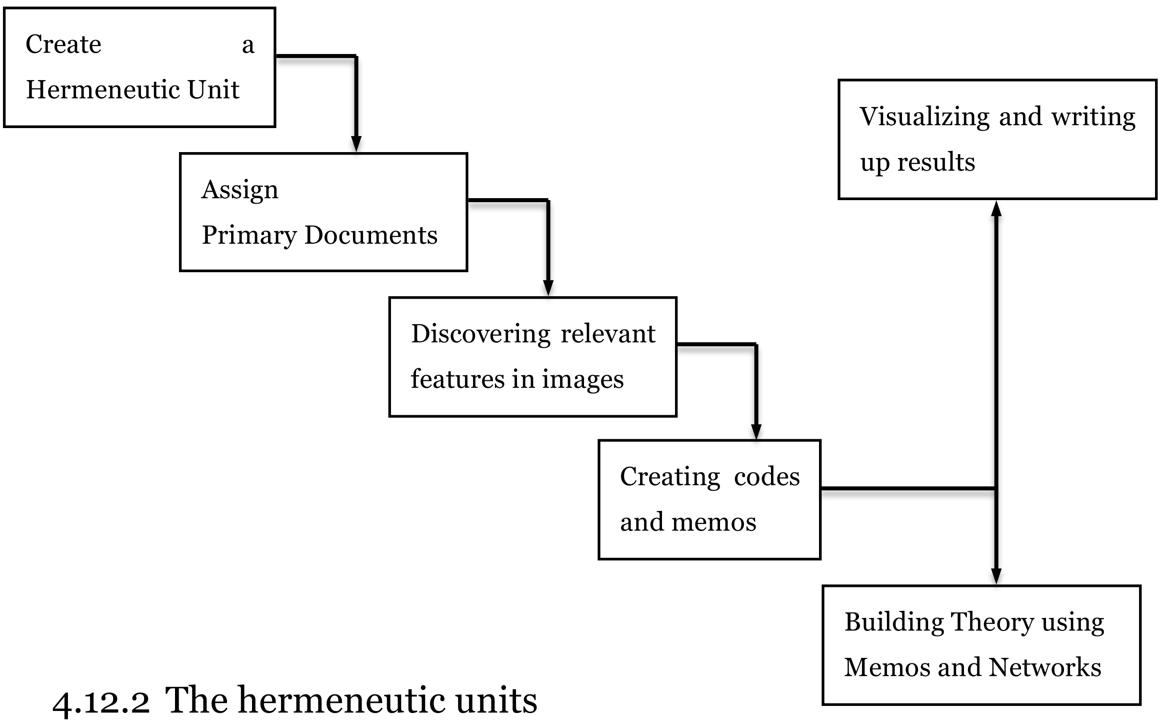
It offers a variety of tools for accomplishing the tasks associated with any systematic approach to unstructured data, e.g., data that cannot be meaningfully analyzed by formal, statistical approaches. ATLAS.ti helps you to explore the complex phenomena hidden in your data. It offers a powerful and intuitive environment that keeps you focused on the analyzed materials, for coping with the inherent complexity of the tasks and the data. It offers tools to manage, extract, compare, explore, and reassemble meaningful pieces from large amounts of data in creative, flexible, yet systematic ways (Altas.ti 5.0, 2004: 2).

ATLAS.ti has been described as an outstanding example of creative software design. Reviewers were particularly impressed by the facility with which one can directly code, query, and analyze text, audio, pictures, video, HTML, and other data types in ATLAS.ti 5.0. This feature alone gives ATLAS.ti a tremendous edge over analogous CAQDAS packages such as NVivo, which can only directly analyze text. ATLAS.ti is an excellent general-purpose QDA package. Interviews and other text-based research may be analyzed using other packages, but once the data move beyond relatively straightforward texts, ATLAS.ti would be an excellent option because it can import, display, code, and analyze such a wide range of qualitative data types (Barry Lewis, 2004: 460-461).

4.12.1 Working with Altas.ti

A project in Altas.ti starts by creating a Hermeneutic Unit or HU, which is a document that holds all the data sources, coding, memos and networks. The next step is to assign data documents, in this case graphic files of drawings and mind maps, as primary documents or PDs to the HU. Each single PD is meticulously studied to identify features in the image that are of particular interest, assign codes and write memos that contain explanatory notes about the features or clarifications as given by the student during the post-visit interview conducted at school. Memos are valuable in recording relevant details not immediately evident in the drawings or the researcher's thinking about the data. The codes chosen can be re-selected for each identical feature on the same image or other images assigned in the HU.

Figure 4-12. Schematic process of data analysis with Atlas.ti

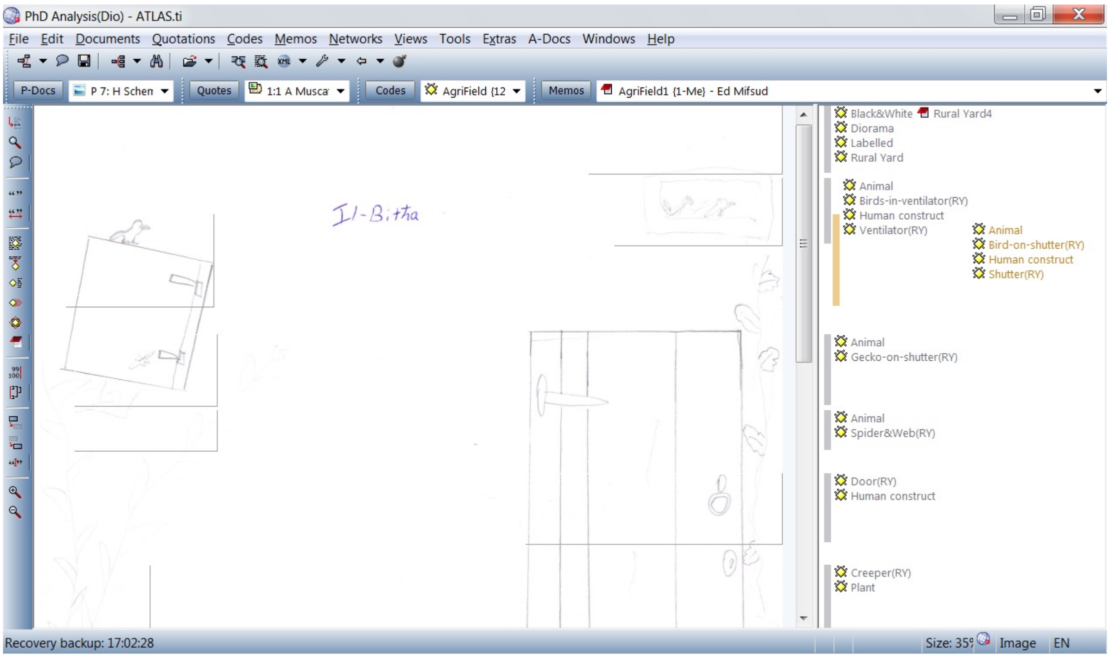


4.12.2 The hermeneutic units

Each drawing and web produced was scanned electronically and saved individually as graphic files (jpg). The hermeneutic units created are mentioned as follows: Class Task, Pre-diorama, Diorama and Web. The Class Task was the HU to which the drawings created in class are assigned as PDs; the Pre-diorama was the HU to which the drawings created at the museum, before viewing the dioramas, were assigned as PDs; the Diorama was the HU to which the drawings created at the museum, after viewing the dioramas, were assigned as PDs and the Web is the HU to which the mind maps (children refer to these as webs) were assigned as PDs. Drawings were very carefully and repeatedly examined to identify relevant features that were subsequently tagged with codes and memos added to record explanations given by the author of the drawing. Memos contain information, which cannot be presented in drawing or is not evident in the graphical composition. This information provides relevant details such as what influenced the child to draw that particular scene or the reasons for choosing to draw a particular diorama or for not drawing another one. Memos are also useful to recount the sequential process of analysis.

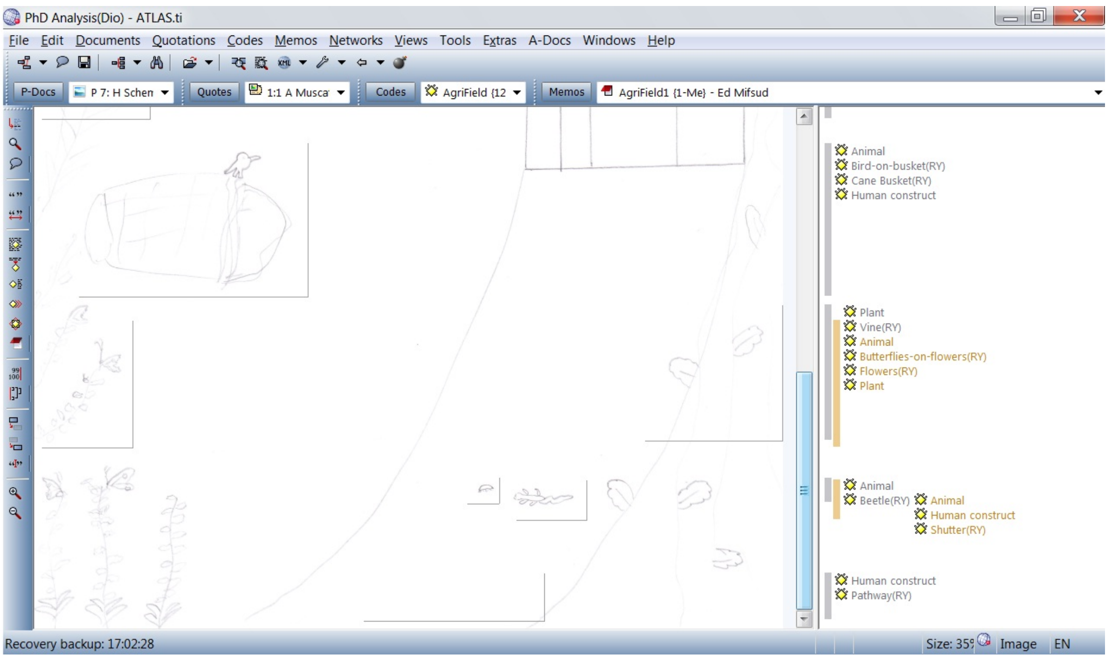
A coding method was developed for analyzing the drawing, in principle similar to emergent analytic coding developed by Haney et al (2004: 252). A list of features that the drawings contain was drawn; each feature was assigned a specific code. The checklist was used to mark codes in each drawing generating a cumulative count. Main code categories, such as animal and plant, were assigned. In the case of animals, taxonomic sub-categories were added to better classify the organisms included. Each animal included in the drawing was linked in the appropriate taxonomic sub-category for example mammal, insect or bird. Sub-categories were not added to the diorama drawings since the organisms presented are pre-selected by the museum setting constructor and children were not free to include any organism they could recall. A feature in a drawing was coded by first selecting it using the PC mouse and than tagging the selected area with the relevant codes. The selected area could include several codes and also memos. The following two images are an example of how each drawing, saved as a graphic file, may be analyzed using the software Atlas.ti.

Figure 4-13. Coding pane in Atlas.ti (example 1).



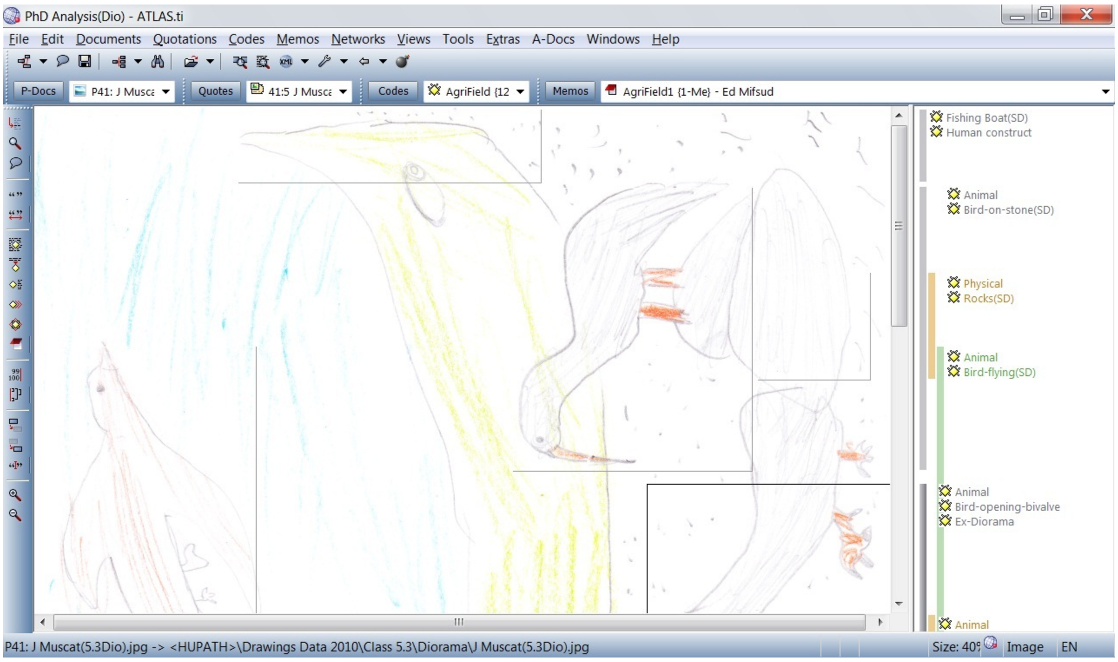
These two pictures show a spit image of a drawing of the rural house yard diorama. The drawing is clearly titled 'il-bitħa' meaning the yard, however it very evidently shows the yard, with many of it's physical features, animals and plants all in their rightful position as located in the diorama. The analysis will be treated in greater detail in the following chapter four, which will present the complete results.

Figure 4-14. Coding pane in Atlas.ti (example 2).



The main section of the screen shows the primary document (drawing) with the selected areas delineated by rectangles. The right hand side of the screen shot is the margin area of Atlas.ti that shows vertical coloured bars, the size of which corresponds with the height of the rectangular area in the drawing. Named codes are tagged to each selected area forming a list that flanks the vertical bars. Different layers of coding are shown in a different colour. It is also possible to attach memos that are denoted by a red notebook icon visible in the first picture above. Below is another example showing a drawing of the sand dune diorama.

Figure 4-15. Coding pane in Atlas.ti (example 3).



4.12.3 Networks

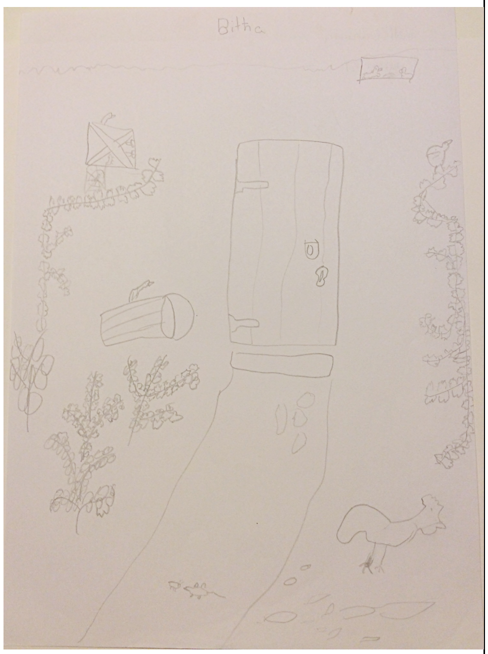
ATLAS.ti offers the possibility of creating graphical networks. An ATLAS.ti network is the set of all objects and their links inside the Hermeneutic Unit (HU). It exists independently of any display-oriented characteristics (layout, color, line width, etc.) and it is actually the logical structure of the HU's objects. In contrast with linear, sequential representations such as text, presentations of knowledge in networks resemble more closely the way human memory and thought is structured. Cognitive "load" in handling complex relationships is reduced with the aid of spatial representation techniques. ATLAS.ti uses networks to help conceptualize the structure by connecting sets of similar elements together in a visual diagram. In the network view it is possible to express relationships between the elements (codes, quotations and memos) that form the network. The elements become nodes, which are any object that is displayed in a network view. It is possible to construct concepts and theories based on relationships between codes and memos. This process may uncover other relations in the data that may not be previously obvious and still allows the researcher to instantly revert to his or her notes or primary data.

4.12.4 Scoring the drawings

A diorama drawing is regarded as an expression of the children's mental model of the particular diorama observed. It was thus important to analyze the drawings in relation to the diorama they are representing. This has important implications in relation to ideas about perception. The diorama drawings are scored on the number of animals, plants and physical features present in the diorama and included in the drawing. The score was given by expressing the number of animals or plants drawn as a percentage of the total number present in that particular diorama. Features in drawings were also scored in comparison to their position in the diorama and also recorded as a percentage. The number of drawings in which all the features were sketched in the same place or in a similar position as that found in the actual diorama was also noted and recorded.

Table 4-4 is an example of how scoring was carried out on a drawing showing the House Yard diorama.

Table 4-4. Scoring a diorama drawing for closeness to actual setting.

<table>
<tr><td colspan="2">Student Nell drew 10 animals out of 16, 4 plants out of 8 and 6 physical features out of 7 for a total of 20 items out of the 31 present in the diorama.</td></tr>
<tr><td>Drawing all of the 16 animals would give a highest score of 10. Since the student drew 10 out of the 16, the score works out as:
$10 \times 10 \div 16 =$ 6 (rounded up)
Plant score:
$4 \times 10 \div 8 =$ 5
Physical score:
$6 \times 10 \div 7 =$ 9 (rounded up)
Total score:
$20 \times 10 \div 31 =$ 6 (rounded up)
Student also drew all 20 items in the correct place as located in the diorama returning a maximum context score as follows: $20 \times 10 \div 20 =$ 10 (max score)</td><td></td></tr>
</table>

4.13 Progressional analysis of drawings

Each set of three drawings produced by each pupil, where analysed to elicit the development progression from Class, through Pre-diorama to Diorama. Children show changes in their drawings as they draw in class and after at the museum during the visit. Some pupils demonstrate noticeable development in the types of fauna and flora they drew, how they elaborated them and if they are presented in habitats or not. The analysis here is derived from a similar one performed in large-scale study at the London Zoo and as part of an assessment of the ZSL London Zoo Formal Learning program (Jensen, 2011). In my analysis I track the different development pathways that children's drawings take, some showing an increased habitat representation while others show a greater elaboration in a single organism.

In the following chapter, data obtained from of the class, pre-diorama and diorama tasks set are presented, together with data from the webs and interviews on all the drawings produced. A progressional analysis from class to pre-diorama to diorama for each pupil is given and shows how drawing develops from the class environment to the museum. Observations of pupils in the diorama area are also included.

The next chapter 5 presents the results from the data collected, with the semi-quantitative and qualitative analysis of the drawings and webs. An example from one pupil as a case study is provided as well as a progressional analysis of the three drawings produced by each pupil.

5 Results

5.1 Analysis of drawings

The software Atlas.ti (essentially a qualitative analysis tool; CAQDAS) was employed to analyse all the drawings produced by the children in class before the NHM visit and at the museum during the visit. The four hermeneutic units created were *Class Task, Pre-diorama, Diorama* and *Web*. In each unit, the respective drawings were included as primary documents (PDs) and each drawing analysed for relevant features. The methodology employed to analyse the drawings was illustrated in the previous chapter. There was a total of sixty three (63) pupils on roll, however one male pupil with Down's syndrome did not participate and another female pupil was refused consent from her parents leaving sixty one (N=61) participants in this research. First I present a semi-quantitative analysis of data that yields general trends.

5.2 The class task

The purpose of classroom drawings was to gauge the children's present familiarity with local flora and fauna before visiting the museum. This hermeneutic unit (HU) includes the drawings (N=61) created in the classroom prior to the museum diorama visit, meaning that the *Class Task* HU comprises 61 PDs. The analysis generated 152 different codes, which were classified into the categories *animal, plant, composition, graphic, human* and *physical*. A code was a relevant feature in the drawing such as a rat, owl or weasel that were all included in the *animal* category. These categories are explained below:

Table 5-1. Class task categories defined

Animal	Any graphical item recognised or explained as an animal or associated with animals, for example eagle, squirrel and leopard.
Plant	Any graphical item recognised or explained as a plant, for example pine tree and sun flower.
Context	Drawing showing organisms in context, for example a farm, valley, garden or county side.
Graphic	A property of graphical nature: colour, black and white, labelling and anthropomorphic feature.
Artefact	Any feature that has a construction or man-made object.
Physical	Any abiotic feature in the drawing, for example sun, rain and soil.

Each different item on a single drawing in the respective category was coded once, meaning that a code of five animals for a drawing means that the child drew five different animals. The highest number of codes (items) in one drawing was 59, while the lowest was 9.

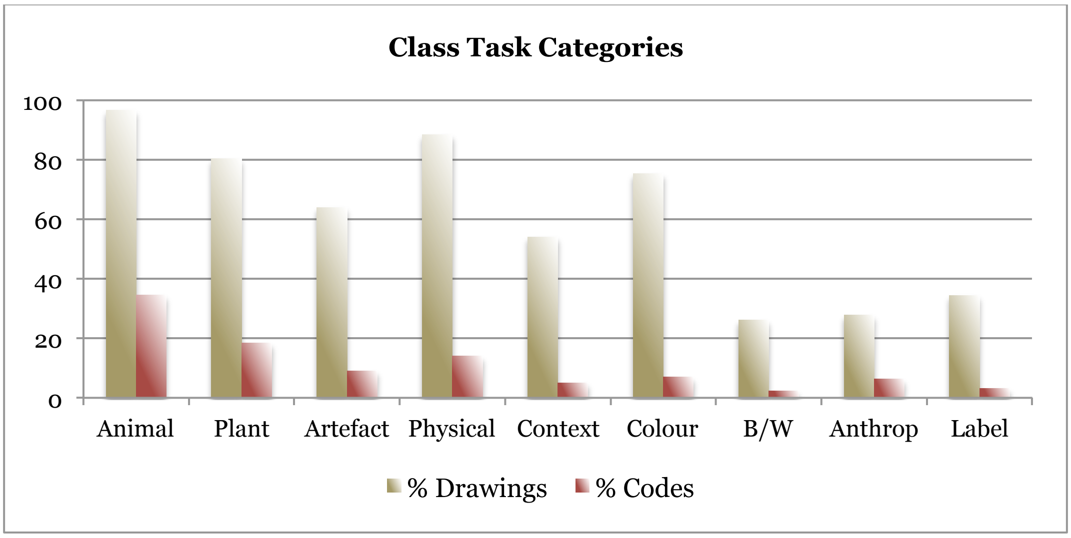
Table 5-2. Class Task HU category drawings and codes.

Category	*Drawings*	*% Pupils drawing feature*	*Codes*	*%*
Animal	59	97	228	35
Plant	49	80	122	18
Context	33	54	33	5
Graphic:			(124)	
Colour	46	75	46	7
Black/white	15	25	15	2
Anthropomorphic	17	28	42	6
Labelling	21	34	21	3
Artefact	39	63	60	9
Physical	54	88	93	14

(Highest codes per drawing: Animal 11, Plant 6, Artefect 4 and Physical 5).

Figure 5-1. shows that the animal category scored the highest number of codes, followed by plants with an appreciably lower number of codes. Almost all drawings (97%) show at least a single animal, while 80% of drawings show one plant. Animal code average per drawing (3.7) was significantly higher compared with that for plants (2.0), bearing evidence to a greater preference for drawing animals rather than plants. Considering the drawing as composition, 54% show organisms in context, while the rest show isolated (unconnected) organisms or out of context. This also explains the 93 physical (abiotic) codes present in all of the 54 (88%) drawings, most of which were features making up the scene such as soil, cloud, wind, river, rain, hills, ground, gravel, rock, sand, water, sea and particularly the sun present in 60% drawings (N=37). Most pupils seemed capable of producing a complete picture showing a scene of a place they were familiar with such as a garden, valley, seaside, glasshouse or shop. In the graphic category, 75% (N=46) drawings were in colour, while 25% (N=15) were in black and white, and 34% (N=21) of drawings show labelled organism. A good proportion (28%) of drawings (N=17) show anthropomorphism. Artefacts were present in 63% of drawings (N=39) showing human constructions (n=60 codes) such as boat, rubble wall, house, glasshouse and road. There were also 3 other codes: *farmer, hunter* and *fisherman*.

Figure 5-1. % Drawings and codes for the categories in the Class Task.



5.2.1 The animal and plant categories

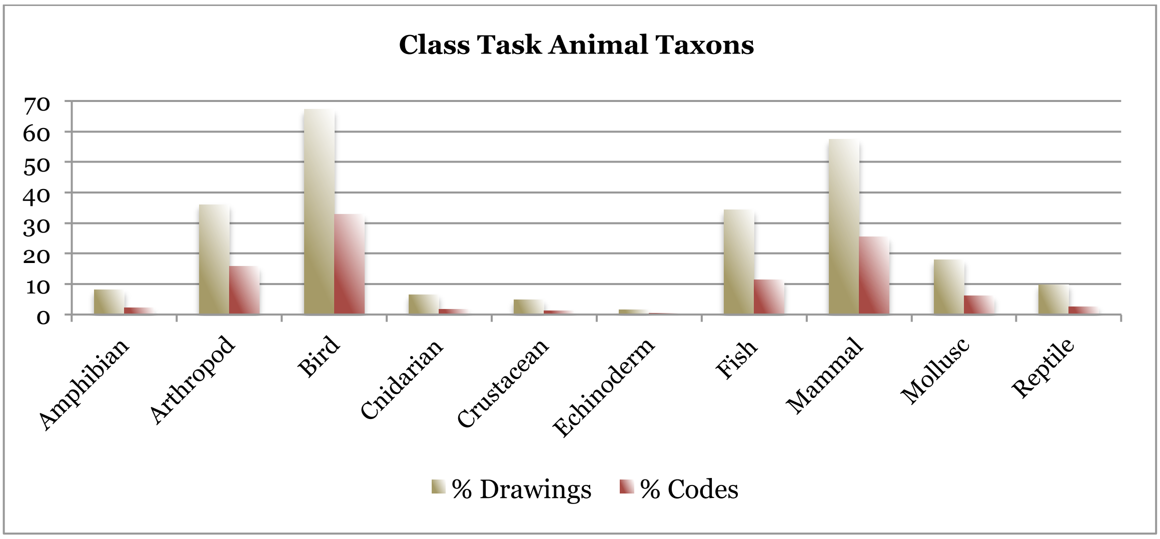
Table 5-3. Class Task animal subordinate group (taxon) drawings and codes.

Taxonomic Group	*Drawings*	*% Drawings*	*Codes*	*% Codes*
Amphibian	5	8	5	2
Arthropod	22	36	36	16
Bird	41	67	75	33
Cnidarian	4	7	4	2
Crustacean	3	5	3	1
Echinoderm	1	2	1	<1
Fish	21	34	26	11
Mammal	35	57	58	25
Mollusc	11	18	14	6
Reptile	6	10	6	3

The number of codes in the animal category was further sub-divided into the subordinate taxonomic groups *amphibian, arthropod, bird, cnidarian, crustacean, fish, echinoderm, mammal, mollusc* and *reptile*. This provides a more detailed picture of the types of animals that the children include in their drawings. The animal category had the largest number of codes (35%) meaning that it showed the highest variety of organisms. More than a third of the animals drawn were birds (33%) followed by mammals (25%), arthropods (16%)

and fish (11%). It was interesting to note the following variety; 15 different species of mammals, 11 species of bird, 5 species of arthropods, 2 species of reptile, 3 species of fish, 2 species of mollusc, one amphibian, one crustacean and one echinoderm.

Figure 5-2. % Drawings and codes in the animal subordinate taxonomic groups.



Drawings do show a lower number of plant codes (n=122) as compared to animals (n=228), but also an appreciably lower variety, with 11 different types of plant compared to 40 animals. The following mainly seeded plants were included: palm, tulip, moss, reed, sunflower, daffodil, apple, olive, orange, peach and pine.

Table 5-4. Type of organism drawn in the respective taxonomic group.

Taxonomic Group	*Organism drawn*
Amphibian	Frog.
Bird	Swan, parrot, chicken, budgerigar, canary, duck, eagle, linnet, pheasant, pigeon and toucan.
Cnidarian	Jellyfish.
Crustacean	Crab.
Fish	Shark and goldfish.
Arthropod	Ant, bee, butterfly, ladybird and spider.
Mammal	Cat, cow, dog, donkey, hamster, horse, human, rabbit, elephant, leopard, lion, tiger, monkey, mouse and squirrel.
Mollusc	Snail and octopus.
Reptile	Snake and turtle.

5.3 The pre-diorama task

The purpose of pre-diorama drawings was to determine whether the novelty of the museum visit would produce any significant effect on the children's drawing compared to that produced in class. This hermeneutic unit (HU) includes the 57 drawings created at the natural history museum prior to the diorama visit, thus the *Pre-diorama Task* HU comprises 57 PDs. The analysis generated 109 different codes, which were also classified into the categories *animal, plant, composition, graphic, human* and *physical.* The categories and their significance are the same as for the Class Task HU. The highest number of codes in one drawing was 43, while the lowest was 8.

Table 5-5. Pre-diorama Task HU category drawings and codes.

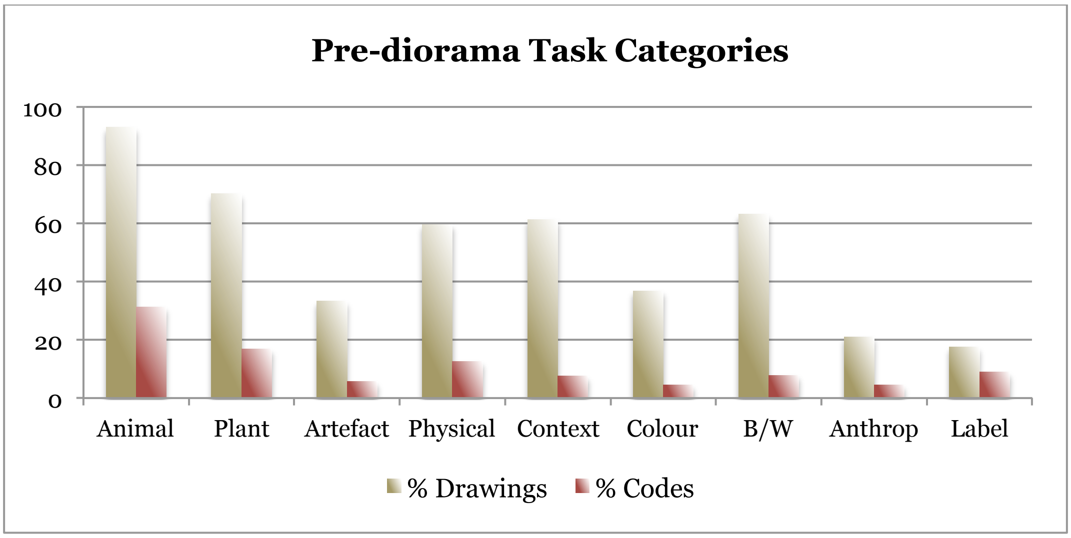
Category	*Drawings*	*% Pupils drawing feature*	*Codes*	*%*
Animal	53	93	144	31
Plant	40	70	78	17
Context	35	61	35	8
Graphic				
Colour	21	37	21	5
Black/white	36	63	36	8
Anthropomorphic	12	21	21	5
Labelling	10	18	41	9
Artefact	19	33	26	6
Physical	34	60	58	13

(Highest codes per drawing: Animal 6, Plant 3, Artefact 5 and Physical 4).

Figure 5-3. shows that the animal category again scored the highest number of codes, with plants scoring almost half the number. Most drawings (93%) show at least a single animal, while 70% of drawings have presence of plants. Animal code average per drawing (2.5) is again much higher than that for plants (1.4), with both averages being considerably lower than the *Class Task.* Compositionally, 61% of drawings show organisms in context compared to the 54% in the class task. Fewer drawings (60%; 58 codes) compared to *Class Task* (88%; 93 codes) show physical (abiotic) codes present in drawings, most of which were features making up the scene such as soil, cloud, wind, cliffs, rain, rock, sea, sky, mountains, cave and the sun present in 24 drawings (44%). In this case also most pupils were capable of producing a complete picture showing a place they were familiar with such as a woods, field, farm, park and garden.

The number of drawings (37%) in colour is half that in the *Class Task* (75%) and organism labelling is also appreciably reduced (10% compared to 34%). A similar proportion (21%) of drawings (compared to 28%) show anthropomorphism. There are considerably fewer pre-diorama drawings (33% compared to 63%) showing artefacts with much less codes (n=26 compared to n=60). Human constructions shown are: aquarium, rubble wall, aircraft, barn and tool, with three other codes *boy, girl, hunter, reader* and *worker*.

Figure 5-3. % Drawings and codes for the categories in the Pre-diorama Task.



5.3.1 Animal and plant categories

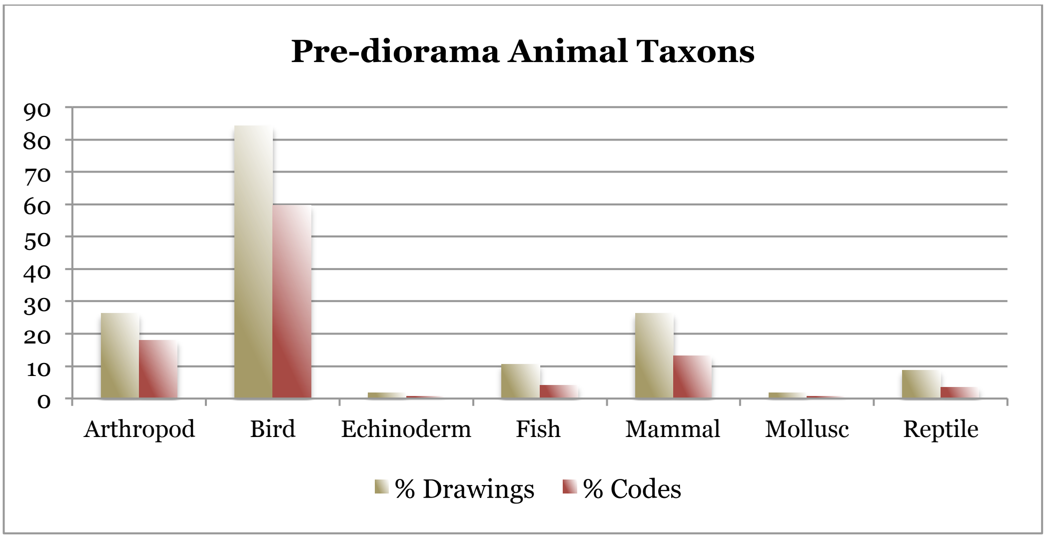
The pre-diorama drawings yielded the following animal subordinate taxonomic groups: *arthropod, bird, echinoderm, fish, mammal, mollusc* and *reptile*. Compared to class drawings no *amphibians, cnidarians or crustaceans* were included.

Table 5-6. Pre-diorama animal subordinate group: drawings and codes.

Taxonomic Group	*Drawings*	*% Drawings*	*Codes*	*% Codes*
Arthropod	15	26	26	18
Bird	48	84	86	60
Echinoderm	1	2	1	1
Fish	6	11	6	4
Mammal	15	26	19	13
Mollusc	1	2	1	1
Reptile	5	9	5	3

Similar to the class drawings, the pre-diorama show the highest variety in animals with a reduced number of codes (n=144) compared to the class task (n=228). There is a clear shift towards birds (60% compared to 33% in class), while more arthropods (18%) than mammals (13%) are seen here. The number of animal species observed is 37 compared to 40. In terms of variety, the pre-diorama drawings show more bird species (16 compared to 11 in class drawing), less mammalian species (10 compared to 15 in class drawing) while arthropods, reptiles and fish species included are very similar in both pre-diorama and class drawings.

Figure 5-4. % Drawings and codes in the animal subordinate taxonomic groups.



Pre-diorama drawings also show fewer plants (n=78) compared to class (n=122) and lower variety of plant species too (5 compared to 11 in class drawings). The following seeded plants are shown: apple, cherry, pine, rose and sunflower.

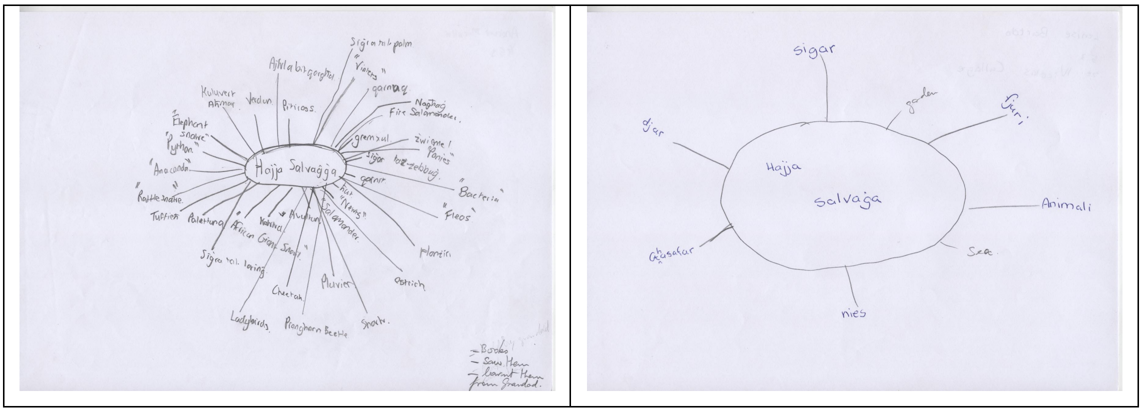
Table 5-7. Type of organism drawn in the respective taxonomic group.

Taxonomic Group	*Organism drawn*
Bird	Crow, duck, flamingo, golden eagle, kingfisher, ostrich, owl, parrot, peacock, pelican, pigeon, robin, sparrow, swan, turtledove and vulture.
Echinoderm	Starfish.
Fish	Swordfish and goldfish.
Arthropod	Bee, butterfly, moth and caterpillar.
Mammal	Bat, cat, donkey, horse, human, mouse, sheep, squirrel, weasel and whale.
Mollusc	Snail.
Reptile	Dragon, snake and turtle.

5.4 The web task

For this task children were asked to create a basic mind map (they call it a web), linking all they know about the central theme *animals/plants*. The purpose of this activity was to elicit what the children know about local organisms, but would not necessarily include in their drawings. A pupil might possess a richer knowledge of animals and plants than his or her drawing might show. The task was denoted as *Web HU* with 57 webs and so yielding 57 PDs. The highest number of total codes in one web was 94 and the lowest was 2, with an average of 33 per drawing.

Figure 5-5. Examples of two quite different webs.

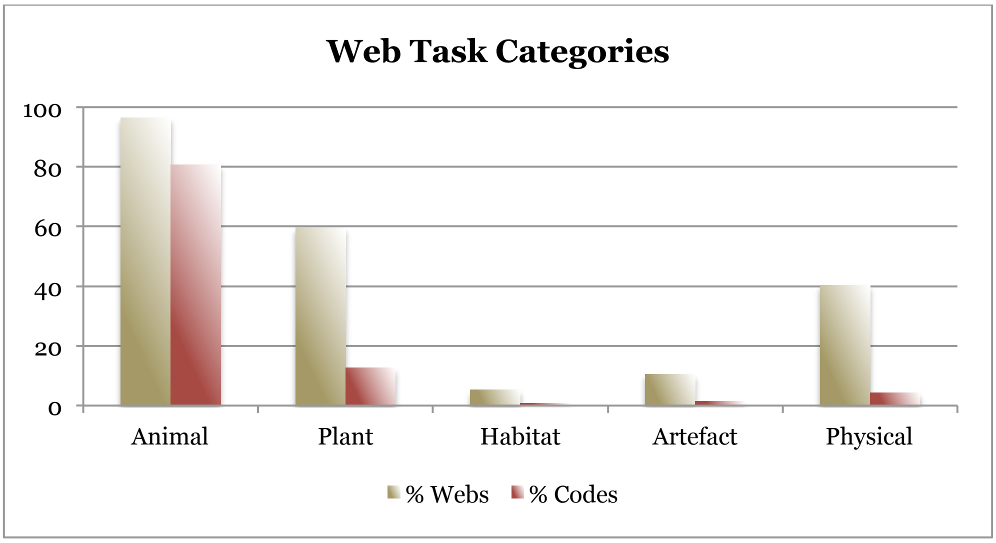


Categories for the *Web Task* were *animal, artefact, habitat, plant* and *physical*. The following animal subordinate taxons are found in the webs: *amphibian, bird, crustacean, echinoderm, fish, insect, mammal, mollusc* and *reptile*.

Table 5-8. Web Task HU category drawings and codes.

Category	*Webs*	*% Webs*	*Codes*	*% Codes*
Animal	55	96	465	81
Plant	34	60	73	13
Habitat	3	5	5	<1
Artefact	6	11	8	1
Physical	23	40	25	4

Figure 5-6. % Drawings and codes for the categories in the Web Task.



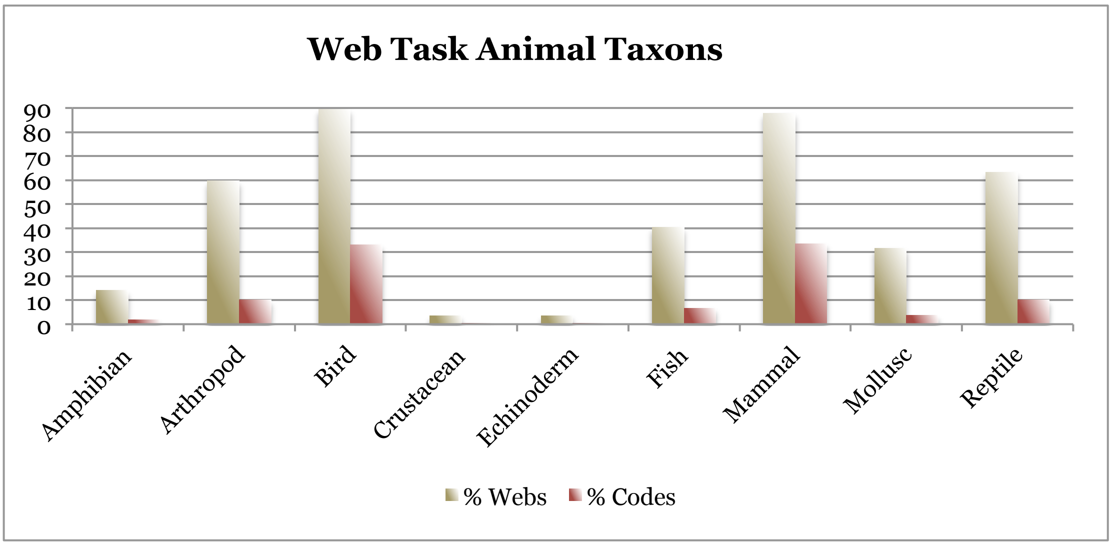
As expected, the animal category again scored a higher number of codes compared to plants (81% animal codes, 13% plants). Only two webs had no animals (average codes of 8.2), while 60% of webs had plants (average number of codes of 1.3). Animal code average was much higher than that of plant, and also appreciably higher than the averages of both the *Class Task* (3.7) and the *Pre-diorama Task* (2.5). So it was evident, that children were able to mention more animals than they were willing to draw. Ninety percent of the webs included a bird and 88% a mammal, with very similar number of codes, followed by reptile (63%), arthropod (60%), fish (40%) and Mollusc (32%). Few webs mention an amphibian, a crustacean or an echinoderm.

Table 5-9. Web task animal category subordinate group drawings and codes.

Taxonomic Group	*Webs*	*% Webs*	*Codes*	*% Codes*
Amphibian	8	14	9	2
Arthropod	34	60	47	10
Bird	51	90	154	33
Crustacean	2	4	2	<1
Echinoderm	2	4	2	<1
Fish	23	40	31	7
Mammal	50	88	156	34
Mollusc	18	32	17	4
Reptile	36	63	47	10

The data show that birds and mammals predominate the knowledge of this pupil cohort. A wide variety of species, mainly birds and mammals are seen in the webs.

Figure 5-7. % Drawings and codes in the animal subordinate taxonomic groups.



One particular pupil (a boy) possessed an impressive knowledge of animal species. During the interview, the pupil said that he liked to read books on wildlife, prefers television documentaries about wildlife, learnt a lot from his grand father and has even travelled to foreign countries to observe wildlife.

5.4.1 Animal and Plant categories

While birds feature to a greater extent in the *Class* and *Pre-diorama* drawings, in the *Webs* mammals (34%) feature slightly higher than birds (33%) followed by arthropods (10%), reptiles (10%) and fish (7%). There is far greater variety here; 40 bird species (compared to 11 in class and 16 in pre-diorama drawing), 32 mammalian species (compared to 15 in class and 10 in pre-diorama drawing), 12 arthropods species, 11 species of reptile, 8 species of fish, three species of mollusc, echinoderm and amphibian, and one crustacean. One boy in particularly, expressed an impressive knowledge about animals, which was rather atypical of the cohort. Generally, children include far more animals in the webs than they do in drawings, with greater variety and likewise dominated by birds and mammals. Reference to plants was slightly lower compared to drawings.

Table 5-10. Type of organism written in webs in the respective taxonomic group.

Taxonomic Group	*Organism written*
Amphibian (3)	Newt, salamander and frog.
Bird (40)	*Given by >10%*: Eagle, flamingo, owl, pelican, rooster, crow, vulture and duck. *Given by <10%*: Penguin, blue rock thrush, hen, hoopoe, mallard, robin, swan, ostrich, stone-curlew, parrot, shoveler, vulture. *Single mention*: Alpine swift, black bird, Eurasian bittern, falcon, goose, great tit, greenfinch, crane, hawk, kestrel, lapwing, little stint, merlin, nightjar, seagull, sparrow, starling, dove, turtle dove and wryneck.
Crustacean (1)	Crab.
Echinoderm (3)	Starfish and sea urchin.
Fish (8)	Swordfish, shark, flying fish, bow fish, African lungfish, ray, hammer fish and mudskipper.
Arthropod (12)	Ant, bee, beetle, butterfly, worm, fly, flea, ladybird, mosquito, scorpion, spider and cockroach.
Mammal (32)	*Given by >10%*: Bat, kangaroo, lion, rat, tiger, weasel, hyena, elephant, monkey and rabbit. *Given by <10%*: human, billy-goat, bull, cheetah, whale, cow, dear, dog, horse, koala, pig, zebra and shrew. *Single mention*: Buffalo, camel, ram, sheep, dolphin, ferret, panda, pony and guinea pig.
Mollusc (3)	Snail, octopus and oyster.
Reptile (11)	Crocodile, lizard, chameleon, dinosaur, skink, gecko, elephant snake, cobra, python and anaconda.

5.5 The diorama task

In this exercise, children had ten minutes to observe freely the five local habitat dioramas, without any intervention from researcher or teachers. Immediately after leaving the diorama room, they were asked to produce a drawing of their favourite diorama. This task was central to the research and provides the main data source.

The purpose of diorama drawings was to find out how the children perceived the diorama, what captured their attention and what they did not notice. The Diorama (HU) included the drawings (N=57) created during the museum visit, meaning that the *Diorama* HU comprised 57 PDs (primary documents). Analysis of these PDs generated 107 different codes, which were classified into the following categories: *animal, diorama, ex-diorama, human construct, meteorological, non-diorama, physical, plant, agrifield, bastion, house yard and sand dune.* The agrifield, bastion, house yard and sand dune refer to four of the five dioramas in the NHM, the fifth being the valley floor that no child chose to draw. The following table explains the categories:

Table 5-11. Diorama Task categories defined

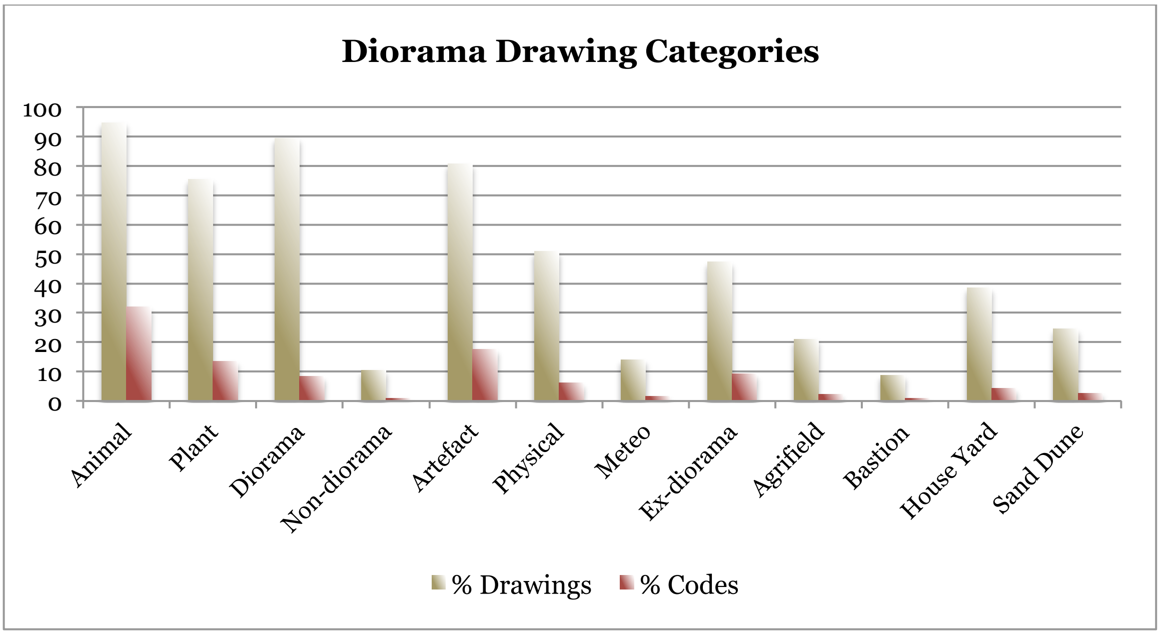
Animal	a graphical item on the drawing recognised or described by the child as an animal found in the diorama.
Plant	a graphical item on the drawing recognised or described by the child as a plant found in the diorama.
Diorama	a composition clearly showing or described by the child as a diorama.
Ex-diorama	a graphical item on the drawing recognised or described by the child as not belonging to any diorama.
Non-diorama	a drawing clearly described by the child as not showing a diorama.
Artefact	any feature on the drawing that was a human construction found in the diorama or out of the diorama.
Meteorological	any graphical item on the drawing associated with climate.
Physical	any abiotic item on the drawing present in a diorama or otherwise.
Agrifield	a drawing showing the agricultural field diorama.
Bastion	a drawing showing the fortification diorama.
House Yard	a drawing showing the house yard diorama.
Sand Dune	a drawing showing the sand dune diorama.

Every item on a drawing in the respective category was coded for all instances it appears. In this case, it was vital to code all items since the aim of the investigation was to elicit how and to what extent the pupils form a mental model of the diorama they preferred. The highest number of codes in one drawing was 44, while the lowest was 6.

Table 5-12. Diorama Task HU category drawings and codes.

Category	*Drawings*	*% Drawings*	*Codes*	*% Codes*
Animal	54	94	165	32
Plant	43	75	70	14
Diorama	53	90	43	8
Non-diorama	4	11	5	1
Artefact	46	81	91	18
Physical	29	51	32	6
Meteo	8	14	8	2
Ex-diorama	27	47	48	9
Agrifield	12	21	12	2
Bastion	5	9	5	1
House Yard	22	39	22	4
Sand Dune	14	25	14	2

Figure 5-8. % Drawings and codes for the categories in the Diorama Task.



Similar to the class, pre-diorama and web tasks, the animal category yielded the largest number of codes (n=165; 32%) with only three drawings lacking animals. Here again, plants score (n=70; 14%) much lower when compared to animals, with artefacts scoring (n=91; 18%) higher than the plants. Most of the artefact codes (68%) are man made structures seen in the House Yard diorama drawings, while the remaining artefacts seen are the fishing boat (Sand Dune diorama), rubble wall (Agrifield diorama), the fortification and the baked beans can (both in the Bastion diorama). According to the curator, the baked beans can was purposely placed in the diorama to attract attention, but surprisingly one pupil only drew it.

Most drawings (82%) were done in grey pencil without any colour, while just over half (55%) of the drawings showed labelling. More than half the drawings (51%) showed a physical feature, with a rather low number of codes (n=32). Most drawings (90%) show one of the diorama settings, with only six drawings (11%) showing something else. Almost half the drawings (47%) feature an object not found in the diorama (Ex-diorama) selected or any one of the other settings. Meteorological features comprise 2% of codes and all being ex-diorama items.

5.5.1 Animal subordinate (taxon) category.

The frequency of codes here confirms the greater preference for birds (58%) as seen in the *Class* and *Pre-diorama* tasks and similar to the *Class* drawings, mammals and arthropods rank highest after birds. The trend of including much more birds than mammals and arthropods among the other taxons is observed through the three tasks.

Table 5-13. Diorama task animal subordinate category drawings and codes.

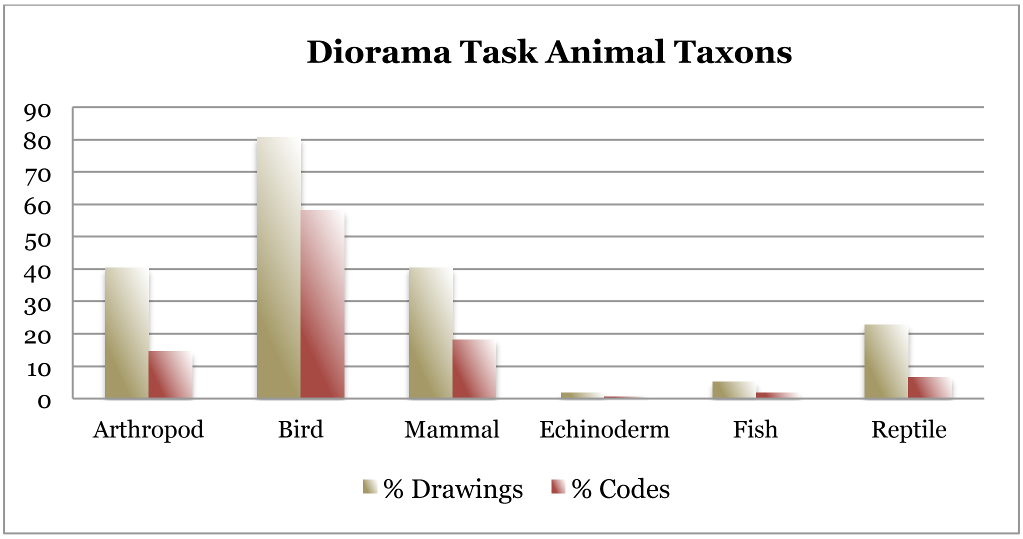
Taxonomic Group	*Drawings*	*% Drawings*	*Codes*	*% Codes*
Arthropod	23[1]	40	24	15
Bird	46[2]	81	96	58
Mammal	23[3]	40	30	18
Echinoderm	1	2	1	1
Fish	3	5	3	2
Reptile	13	23	11	7

1. At least one arthropod is included in drawing: 2 (>1) and 1(3).

2. At least one bird is included in drawing; 32 drawings show (>1), 17(>2), 7(>3), 5(>4) and 1(6).

3. At least one mammal is included in drawing; 6 (>1) and 2 (3).

Figure 5-9. % Drawings and codes in the animal subordinate taxonomic groups.



5.5.2 Diorama and ex-diorama

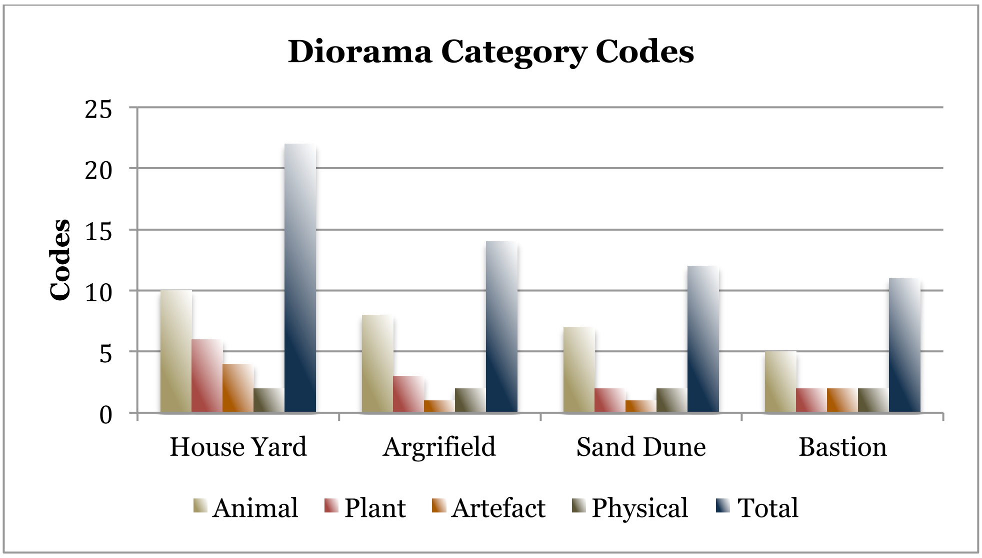
The drawings (N=53) showing a diorama are divided as follows: 12 agrifield, 5 bastion, 22 house yard and 14 sand dune; four drawings show something other than a diorama. The House Yard attracted most pupils (39%), while almost an equal proportion of children preferred the Agrifield (21%) and Sand Dune (25%). The bastion was the least appealing to children (9%), while no one selected the Valley Floor.

Table 5-14. Different items noticed and drawn from the four Dioramas selected.

Diorama	*Animal*	*Plant*	*Artefact*	*Physical*	*Total*
House Yard	10	6	4	2	22
Argrifield	8	3	1	2	14
Sand Dune	7	2	1	2	12
Bastion	5	2	2	2	11

Children seemed to notice most features (22) in the house yard diorama, while in the other three they noticed a similar number of features (figure 4-9). The general trend showing that animals were the most noticed and plants appreciably less was observed in this case too.

Figure 5-10. Codes of the different features drawn in the dioramas selected.



Children's drawings also contained 15 animals, 8 plants, 4 meteorological, 2 physical and 1 human construct feature not present in any of the dioramas. That was evidence of the tendency to insert organisms or objects from outside the diorama (Ex-diorama) into the diorama drawing.

5.6 Diorama drawing in relation to the exhibit

All drawings were also analysed for content in relation to the animals, plants and physical (abiotic) features in the diorama. Drawing content was analysed for number and position of items present in the setting and scored for animal, plant, physical and context. The score was given on a scale from one to ten (1 – 10) expressing the number of drawn features compared to the actual number in the diorama and also their position in it. A scoring example is given in section 4.12.4 (in chapter 4).

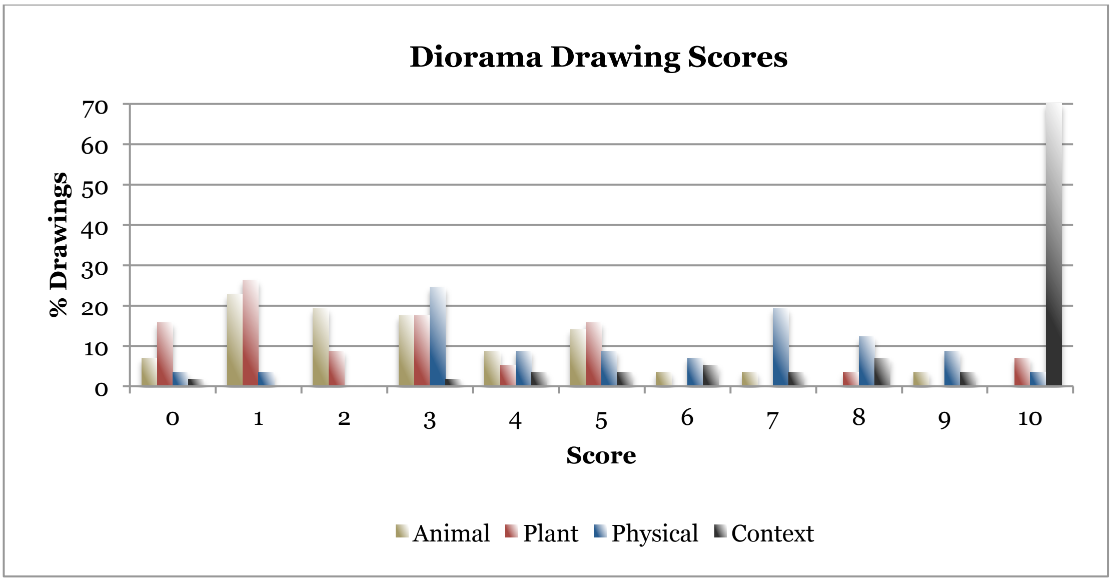
Figure 5-11. below shows the scores for animal, plant, physical and context aspects of the diorama drawings. Animal and plant refer to any such organism from the diorama present in the drawing. Physical refers to all abiotic components from the diorama, while context refers to the degree of closeness between the drawing and the actual diorama setting.

Table 5-15. Diorama drawing compositional scores.

Score	% Drawings			
	Animal	Plant	Physical	Context
0	7	16	4	2
1	23	26	4	0
2	19	9	0	0
3	18	18	25	2
4	9	5	9	4
5	14	16	9	4
6	4	0	7	5
7	4	0	18	4
8	0	4	12	7
9	4	0	9	4
10	0	7	4	70

Most drawings, 82% scored from 1 to 5 for animal, 89% scored from 0 to 5 for plant, 81% scored from 3 to 8 for physical, 88% from 1 to 5 for total features and 81% from 8 to 10 for composition. Animal and plants scored rather low, physical scored higher while composition scored the highest. Few children included more than half the animals and plants in the diorama, while they tended to draw more of the physical features of the setting. Notably, 70% of the drawings showing a diorama displayed all items in the same location as they occur in the diorama: 16/22 house yard drawings, 8/12 agrifield, 10/14 sand dune and 3/5 bastion drawings.

Figure 5-11. Scores of the main features drawn in the diorama drawings.



5.7 Case study of one pupil

Here I present a complete data set of one pupil (Andrew), that is, the three drawings produced, important points that emerge from interviews on the drawings, the web and comments from the conversations in the diorama hall.

Figure 5-12. Class drawing by Andrew.

In the Class drawing the pupil represented a forest. The items drawn are a) plants: four trees, felled tree, grass undergrowth; b) animals: an eagle, a Toucan, rattlesnake, cobra, leopard, frog and crab in a lake and an insect caught in a spider web attached between two trees. Trees show the standard two-dimensional trunks with branching and the crown's contour assumes an undulating pattern with dimensions that are wider than the trunk, but not showing any individual leaves.

All animals are drawn in two-dimensional horizontal body displayed in side view, except for the insect and the eagle. The latter is presented in aerial view with wings spread horizontally and placed in a central position on the page. The Toucan is in side view with a prominent beak and with head, body, and tail aligned horizontally. The rattlesnake is displayed in a long wavelike and curved body suggestive of its motion. The cobra and insect are disproportionately large, while the cobra appears static with an over sized head. The desire to create a likeness to the real object is clear in the leopard, insect and especially the Toucan. There is also an attempt to show motion in the leopard, eagle, frog and crab.

Compositionally the drawing is quite balanced, with symmetrically placed items on the page. The spider web and insect are in the center, along the vertical midline of the page that confers a degree of prominence and stability on the figure. Most items are placed at the bottom of the page, as children usually tend to do, but thematic complexity is evident and also the use of logical colour choices. The open space above represents the sky (not coloured blue) with evident presence of the eagle and the sun drawn in Mandala style in the corner. Although there does not seem to be a direct ecological link between the items, the representation suggests that the figures belong together constituting a unit in nature. A coloured background can unite separately presented items, but in this case this is not observed and instead the flora and fauna are only linked thematically.

When interviewed on the drawing, the boy confirmed the identity of each object and stated that this was a forest. He was inspired by visits to foreign countries, in particular by a trip to the Amazon forest. He enjoys reading about nature and wildlife, and he also enjoys listening to his grand father talking about wildlife. He wished to draw more snakes and birds, but did not have enough time to do so.

Figure 5-13. Pre-diorama drawing by Andrew.

In the Pre-diorama drawing the pupils represented a park. The items drawn are a) plants: one tree showing just a trunk, grass undergrowth and one flower; b) animals: bird, moth, snake, fish and duck in pond and two bird nests in tree. The tree shows the standard two-dimensional trunk with branching, but no crown included.

In this drawing animals are also drawn in two-dimensions with horizontal body displayed in side view, except for the moth. The bird and moth are presented in aerial view with the moth placed centrally on the page. The duck is in side view with a clear beak and with head, body, and tail aligned horizontally. The snake shows a particular colour pattern and displayed in a long wavelike and curved body showing its motion. Items are mostly proportionately displayed, with only the moth appearing over sized in comparison. The desire to create a likeness to the real object is seen in the moth, snake and especially the duck. An attempt to show motion is evident in the snake, moth and bird.

This is also a balanced drawing, but less symmetrical than the Class drawing. The moth is placed in the center here, along the vertical midline giving prominence to the insect. Once again most items are placed at the bottom of the page, with the evident park theme and logical use of colour. The open space above is not coloured blue, but it evidently represents the sky with a Mandala style sun in the corner. A direct ecological link between organisms is not obvious, but the representation implies that the figures belong together in a natural unit. In this drawing the background is not coloured, except for the lower part with the glass undergrowth. However, even in this case the flora and fauna are thematically linked.

When interviewed on the drawing, he did not have much to add to what he drew. He confirmed the identity of each object and stated that this was a park. Again he was inspired by a visit to foreign country, in this case a park he visit while in England.

Figure 5-14. Diorama drawing by Andrew.

In his Diorama drawing task, the pupil was one of few to choose the Bastion. Part of the trunk with no leaves and Eucalyptus are included, but the capers were omitted. Fauna included were the bat flying, Night Heron on trunk, Brown rat on rock and the Barn owl in bastion window. The following animals were omitted: Weasel on rock, Spurge Hawk moth on bastion, and resting bat and Starling both on tree trunk.

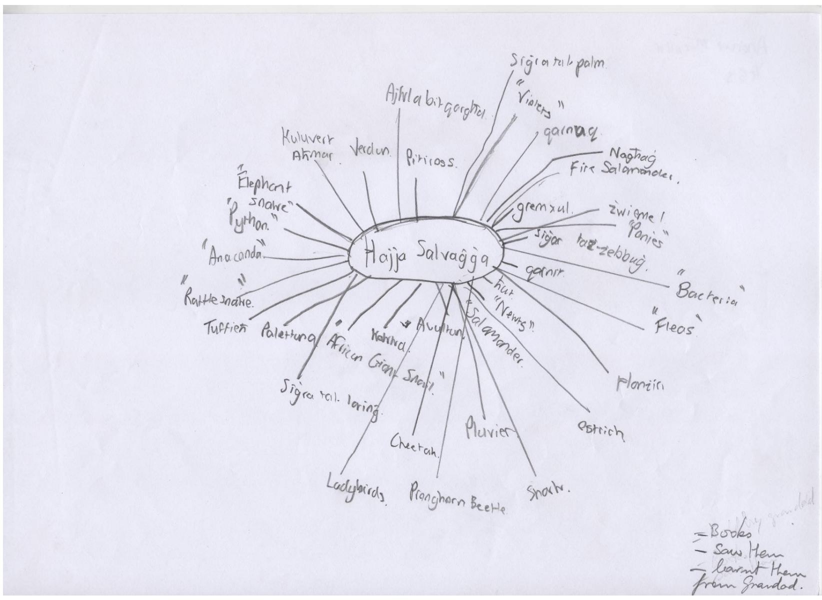
All animals are drawn in two-dimensions with horizontal body displayed in side view, except for the bat that is presented in aerial view with wings spread out horizontally. The flying bat is disproportionate in relation to the rest of the items in the picture, while the Barn owl is only partially represented by the head and large eyes. The desire to create a likeness to the real object is only evident in the flying bat. The rat is displayed with all four legs in-line and bears little likeness to a brown rat. The rocks and stones on the floor are clearly shown in the lower section of the drawing. Worth noting is the inclusion of the baked beans can, placed purposely by the curator to attract attention and highlight human interference in habitats.

Compositionally the drawing is less balanced compared to the previous two and is rather unsymmetrical. The Barn owl is placed in the upper central position, with fewer items placed at the bottom of the page. The upper part of the drawing does not represent sky or items one expects to see in the sky, but shows the cut stone slabs that make up the fortification represented in this diorama. The lower background is here also left devoid of colour with items appearing somewhat unlinked and isolated.

Although there is a common style and representational mode in the plants and animals drawn in the three drawings, there is a clear organizational difference in composing the picture here with the previous two drawings. This drawing was done from observation of a particular museum setting, with items located in distinct positions and so the pupil was not at liberty to draw the various feature where ever he desired, even if he could have done so anyway. In the Class and Pre-diorama task the pupil was drawing mainly from imagination, that is, from the mental image of the place he set out to represent on paper.

The boy was rather reticent during the interviewed on this drawing. He again confirmed the identity of each item included and that the diorama selected as actually the Bastion. He also confirmed that this was his favourite of the five dioramas he observed, mainly due to the types of animals present in it. He did notice the weasel that he did not draw due to time limits. Reading and visits to foreign places of interest account for his rich biodiversity knowledge, for which the extensive web is ample evidence.

Figure 5-15. Web by Andrew.



This student's web was very detailed with numerous organisms mentioned compared to the other pupils' webs. This web included 5 different trees; and each of the following different types of animal: 9 birds, 5 mammals, 5 reptiles, 3 amphibians, 3 insects, 2 fish and a bacterium. The variety of species mentioned is quite remarkable, the birds being mainly local or migratory species, while the rest are mostly non-local species. The preference for birds followed by mammals and reptiles can also be noted here, notwithstanding that the pupil possessed a greater knowledge of flora and fauna.

In the diorama hall, the group that Andrew was in were quite active and a girl was leading the rest. This pupil, being rather reserved, did not speak much but he was very attentive and seemed intent to capture as much detail he could. He did mention the weasel and baked beams tin in the bastion diorama.

5.8 Analysis of change in drawings

Drawings by different children tend to vary considerably and only allow for generalised data presented in the previous sections. However, it is also useful to analyse sets of drawings by the same child that may reveal similarities in detail that illuminate the influences on how the animals and plants in the dioramas were interpreted and visualised. Looking at each child's set of three drawings sheds light on the developmental level attained throughout the tasks set. Almost half the pupils (47%) show a development toward greater variety and increased habitat representation or (28%) greater detail in organism representation without enhanced habitat representation. Some pupils' (25%) drawings show an opposite effect, that is, loss of habitat, reduced variety or more basic organism representation.

5.8.1 General trends

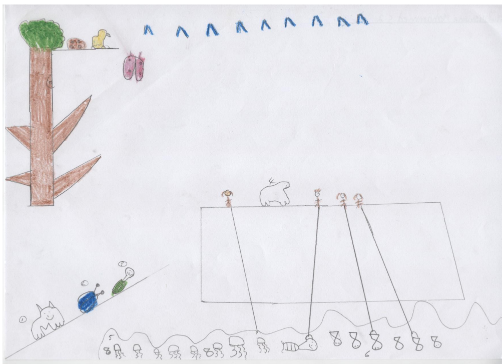
The predilection for birds seemed to be confirmed through the preference for the dioramas (*House Yard*, *Sand Dune* and *Agrifield*) that contain a greater number of birds compared to the other three. Those pupils who drew very few items and in a basic mode did so in all of their three drawings. However, pupils that only drew one bird (or other animal) did so with greater accuracy and detail.

Most pupils (82%) included a similar number of birds in all three drawings and with similar iconic mode for the birds drawn (64%). A third (31%) used a different iconic representation in the diorama compared with the previous drawings. A majority of students (60%) show birds in flight, with 23% of cases flight is shown in all the three drawings. Children that drew flying birds in previous drawings selected a diorama that shows a flying bird (Sand Dune) or bat (Bastion). Others that selected another setting (such as House Yard) actually preferred one of the other dioramas showing birds in flight. Very few drawings (7%) show a feeding relationship. Very few pupils show anthropomorphism, only one pupil did in all drawings, while nine pupils did in only one of their drawings.

The importance of the organism to the child was highlighted by placing it in the center of the picture, drawing it larger or colouring it. Almost half the pupils (49%) drew birds in a central position in the three drawings, 30% drew different organisms in the center in the different drawings, while in 21% of cases comparison was not possible since either no organism was drawn or it was drawn off center.

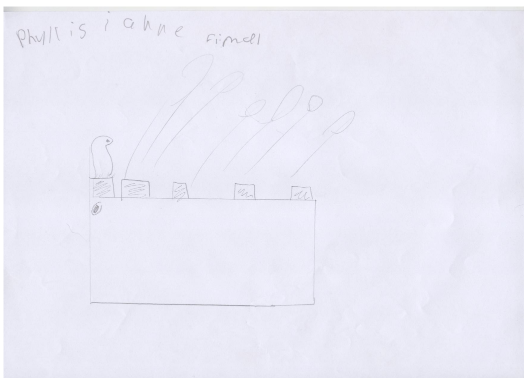
Figure 5-16. Drawings by Phyllisianne.

Class Drawing



Pre-diorama Drawing

Diorama Drawing



In some drawings one can note a common theme in all drawings e.g. seaside. The dioramas are only five selected constructed habitats, which offer children a limited choice of interests to relate to. So those that had a favourite place such as the seaside could relate to the Sand Dune setting with the very prominent Maltese boat, as exemplified by Pauline's drawing in figure 4-11 above. Others settled for a setting, which was the closest image of the place they thought of and drew previously. For instance those (42%) that drew a garden or the countryside selected the 'field' or the 'house yard' that may elicit memories of things one sees in gardens or in the countryside. A few had difficulty to decide which setting to go for and tried to solve the problem by merging two or more dioramas in one picture. Their work shows selected features from different dioramas used to produce a composite drawing as can be seen in figure 5-17.

Figure 5-17. Drawing by Kurt – merging dioramas.

Class Drawing

Pre-diorama Drawing

Diorama Drawing

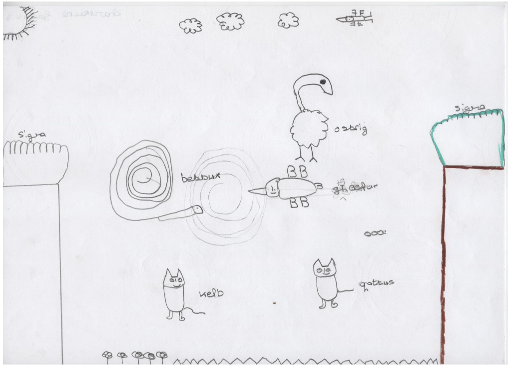
Kurt first drew a garden in class and the pre-diorama with trees, flying birds, nesting birds, a person on a bench, clouds and the sun. He then included some features from the previous drawings (clouds and sun), added a butterfly in the center and merged these with features from the house yard (on r.h.s of drawing) and the bastion (on l.h.s). He tapped into various visual stimuli to produce quite an elaborate composite diorama drawing. This instance shows how intricate the drawing process can be for the child that seems to be accommodating the newly acquired knowledge into his previous mental model.

5.8.2 Change towards greater variety and habitat representation

Nearly half (47%) the pupils participating show a development toward greater variety and increased habitat representation through the three drawings produced. The main changes noted are: from isolated (not in habitat) animals towards increased ecological sense with more accuracy in placing organisms in habitat, narrative shown in drawing, greater elaboration in organism representation and from charismatic animals to non-charismatic. Greater sophistication is observed in a good proportion of the diorama drawings (47%) that show perspective both in terms of relative sizes of organisms, but also in their position in space and in relation to each other. However, perspective was completely lacking in others. The sense of perspective in the constructed dioramas is reflected in some drawings, but not in others. The following are some representative examples that illustrate these observations.

Figure 5-18. Increased habitat representation by Paolo.

Class Drawing

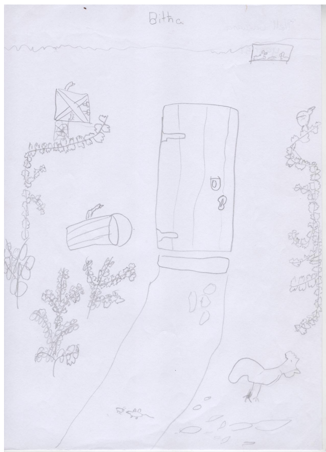


Pre-diorama Drawing

Diorama Drawing

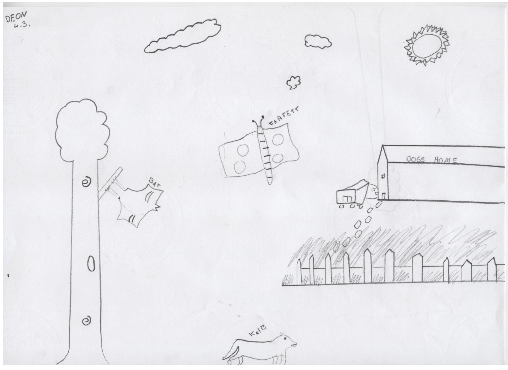
Class drawing shows isolated animals and trees with no evident relationship, while pre-diorama shows butterfly, bird and human in context of a habitat. The diorama drawing is a well-represented sand dune, with one flying bird (in action) and another on the boat, and an iconic sun. Pre-diorama and diorama drawings are very colourful in contrast to the class drawing. The habitat is clearly shown here and the diorama has helped the student to place the organisms with greater accuracy. This pupil seems to have acquired the narrative of the setting. Birds and plants are drawn in iconic mode, while the human disappears but sun is inserted in the diorama.

Figure 5-19. Increased habitat representation by Nell.

<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

There are only isolated animals in class drawing, pre-diorama drawing shows a basic level of habitat representation, while the diorama drawing has animals in the house yard habitat and with some degree of perspective. There is better habitat representation in the diorama with animals in iconic mode, but plants are represented in a more realistic mode. A sense of habitat and ecology has been acquired in this case.

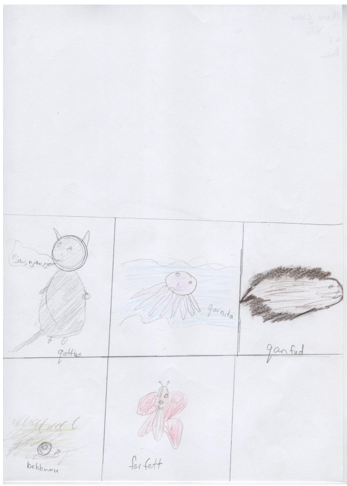
Figure 5-20. Better habitat representation by Deon.

<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

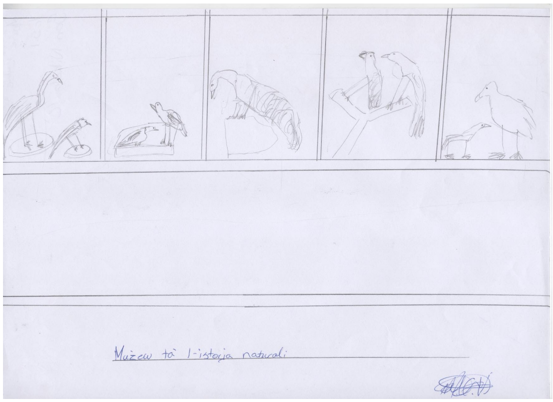
The class drawing shows some context although not a clear habitat, but pre-diorama drawing does not show any real narrative, with an oversized very well drawn bird in the center, which is not connected to the rest. There is a *hunter* shooting at a bird on the more realistically drawn tree. The diorama shows a habitat with few animals and no plants, but animals change from charismatic pheasant to the non-charismatic shrew, beetle and small bird.

Figure 5-21. Increased habitat representation by Marie Cloe.

Class Drawing



Pre-diorama Drawing



Diorama Drawing

The class and pre-diorama drawings only show isolated birds with no sense of habitat. Diorama drawing shows the agrifield with most of the animals (in habitat context) present in the setting drawn in proportion and in perspective. Setting has helped the student to place the organisms with greater accuracy in the habitat. Pupil also seems to have acquired the narrative in the setting.

Figure 5-22. Improved habitat representation by Lenise.

Class Drawing	
	
Pre-diorama Drawing	**Diorama Drawing**
	

Class and pre-diorama are two very similar imaginative drawings, very colourful with some degree of perspective, but with an oversized butterfly in the center. There are fewer animals and flowers in the pre-diorama drawing, while diorama drawing is in perspective, with butterflies and rooster in proportion to plants. In this case too, pupil moved from an imaginative mode to a realistic mode, but with reduced variety and richness in organisms.

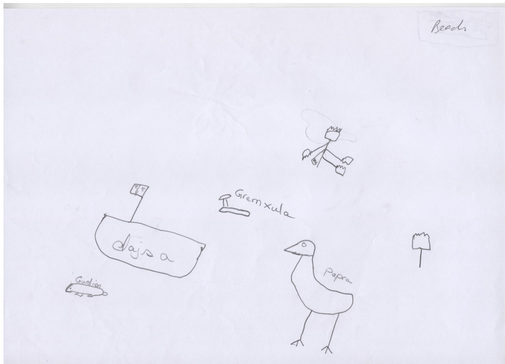
Figure 5-23. Improved habitat representation by Jeremy.

Class Drawing

Pre-diorama Drawing	Diorama Drawing
	

Class drawing shows no real narrative, but five ducks isolated from two trees shown a saprophytic relationship with mushrooms. Habitat appears in pre-diorama drawing with more accurate charismatic birds conflated in a local habitat (Dingli Cliffs) showing the rock strata of the Maltese Islands. This transformed to S*and Dune* with many birds (now iconic) showing feeding relationships, but accuracy lost and oversized. This is one of few rare cases where the pupil used colour in the three drawings.

Figure 5-24. Improved organism representation by Claire.

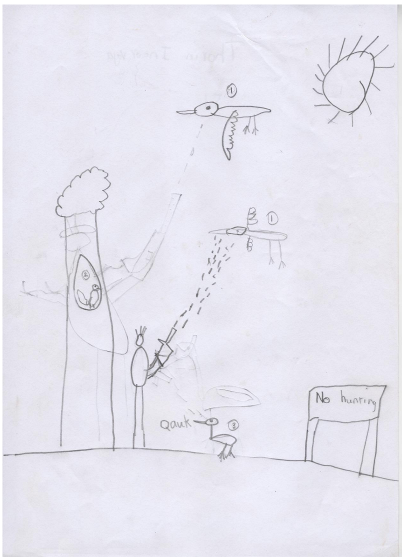
<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

The class and pre-diorama drawings just show the pupil and her brother flanked by two threes which transformed into a picture showing isolated animals, flowers and the sand dune boat. The diorama seems to have helped her to focus on drawing animals albeit not in context of a habitat.

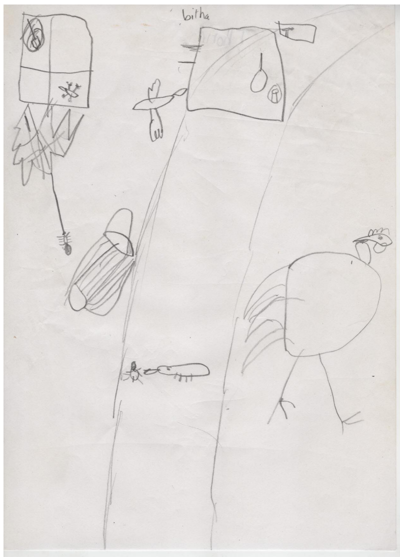
Figure 5-25. Improved habitat representation by Thorin.

Class Drawing

Pre-diorama Drawing



Diorama Drawing



Only ten isolated iconic animals seen in class drawing. The pre-diorama drawing shows a *hunter* shooting at bird, no habitat shown but pupil included a 'no hunting' sign evidencing animal welfare and environmental concern. Diorama drawing roughly shows the house yard habitat, with oversized animals and no perspective. There is a development in that the pupil is now being able to construct a habitat, but no sense of proportion is shown in the last drawing.

5.8.3 Change towards greater organism elaboration

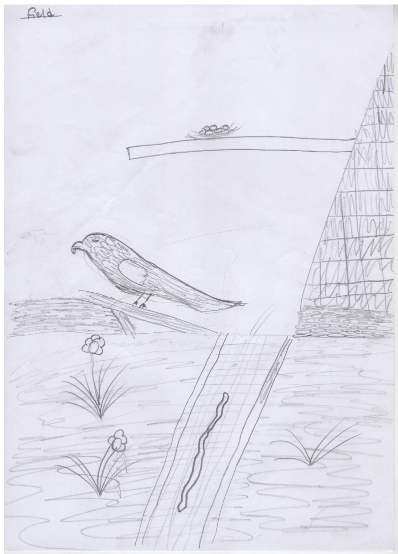
A good proportion of pupils (28%) do not show any substantial change towards increased habitat representation, but they instead focused on producing more elaborate organisms. The following are two examples of this type of change.

Figure 5-26. Elaboration in organism representation by Kurt.

Class Drawing

Pre-diorama Drawing

Diorama Drawing



The first drawing is a careful study of a bird's head, while the pre-diorama drawing shows two elaborately drawn parrots, in both cases isolated and with no sense of habitat. The diorama drawing is a conflation of field and bastion with the same graphically presented parrot inserted in the setting. There is a clear sense of habitat in the diorama drawing, but the parrot is not found in this setting. So the change in this case is from a strongly focused study to a more generalised representation.

Figure 5-27. Elaboration in organism representation by Matthew.

Class Drawing

Pre-diorama Drawing

Diorama Drawing

This set of drawings shows how Matthew is clearly versed towards producing single elaborate birds, rather than pictures showing some form of narrative. The duck in the diorama drawing is more realistically drawn compared to the previous two birds, recognisably a *Mallard* (specimen found at museum).

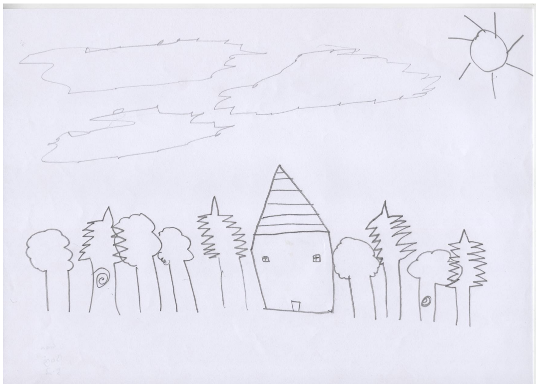
5.8.4 Change towards reduced variety and elaboration

In 25% of cases, drawings evidence an opposite change from class to pre-diorama to diorama. The following three examples show that there were pupils who produced a more elaborate drawing in class compared to those done at the museum before and after the diorama viewing. Changes observed were from animals in an ecological setting to isolated organisms, with reduced variety and elaboration as the pupils progressed from the class to the diorama drawing.

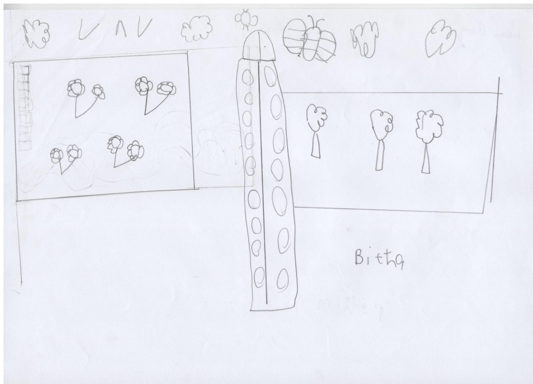
Figure 5-28. Change toward reduced habitat representation by Liam.

Class Drawing

Pre-diorama Drawing



Diorama Drawing

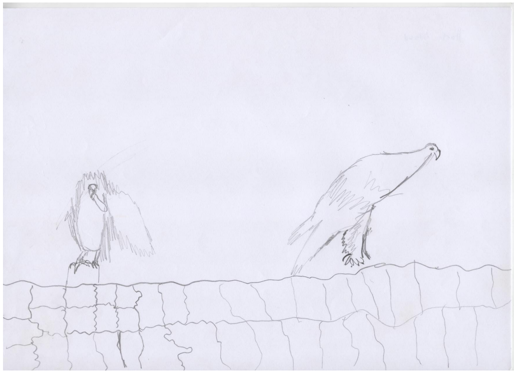


Class and pre-diorama drawings are very similar, the first in colour and shows the charismatic lion, while the second is uncoloured with no animals. The diorama drawing shows V-shaped birds and iconic butterflies with quite a few iconic flowers and trees, but no sense of perspective and reduced elaboration.

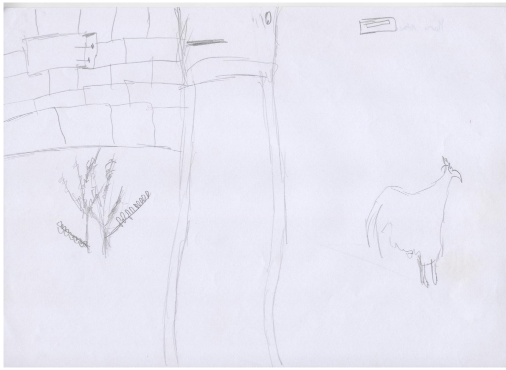
Figure 5-29. Change toward reduced variety by Mark.

Class Drawing

Pre-diorama Drawing



Diorama Drawing

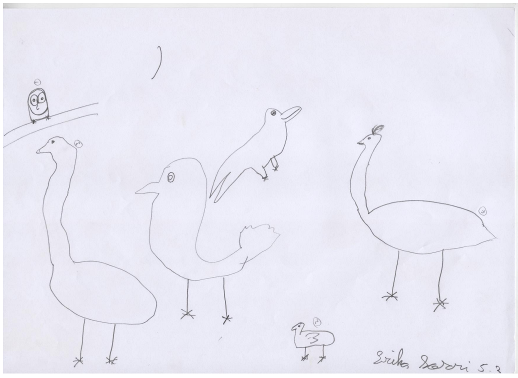


First drawing shows various vertebrates and invertebrates in an ecological setting, with feeding and reproduction in evidence. The second drawing shows just two birds not in an evident habitat setting, while the diorama drawing has just a rooster in a partially represented house yard setting. There is a clear reduction in variety and ecological representation from class to diorama.

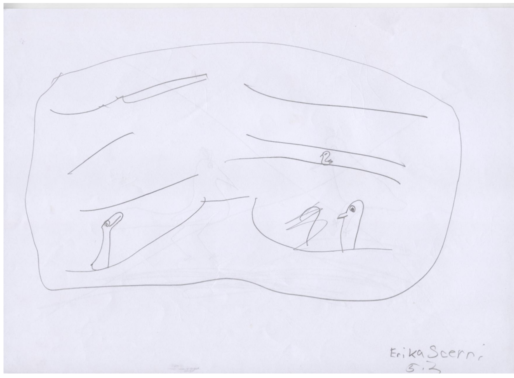
Figure 5-30. Change toward reduced elaboration by Erica.

Class Drawing

Pre-diorama Drawing

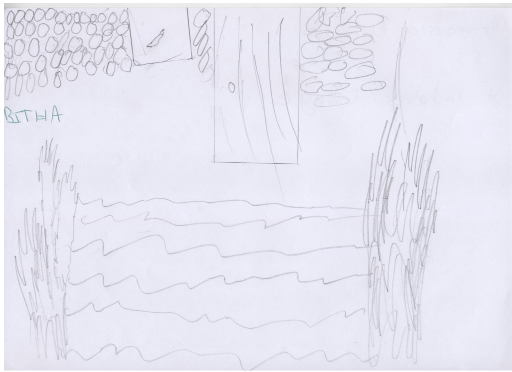


Diorama Drawing



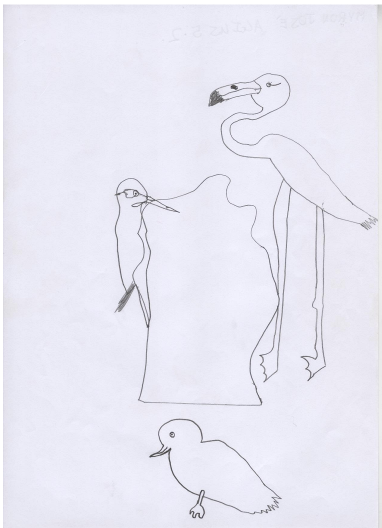
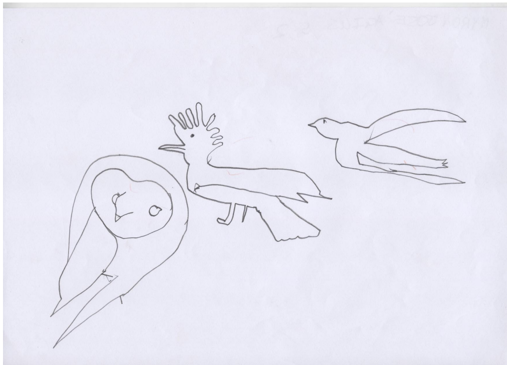
Here we have a highly elaborate class drawing showing flying birds, breeding bird, ducks and fish, with a strong sense of perspective and colour. This transformed to just isolated and unconnected birds drawn in greater detail in the pre-diorama and just three less elaborately drawn birds from a partially represented sand dune diorama with no perspective.

Figure 5-31. Change toward reduced variety and habitat by Francesca.

<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

Another highly elaborate and colourful class drawing showing a girl and a few animals and plants. This changes to a pre-diorama drawing with fewer animals, the human is omitted, but an anthropomorphic sun is included. The diorama drawing has no perspective and just the gecko and grass included are shown.

Figure 5-32. Change toward reduced habitat by Myron.

<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

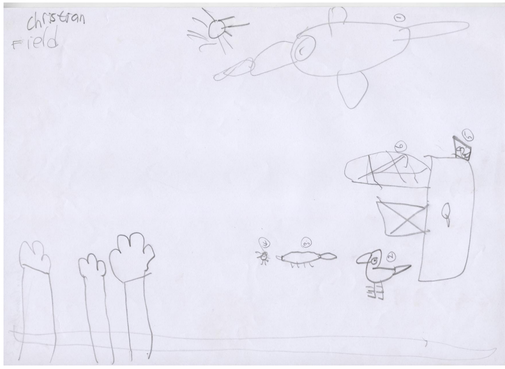
In this set, it is clear how Myron's drawings changed from a habitat to isolated birds, but which are much more elaborately drawn although not in a habitat setting.

Figure 5-33. Change toward reduced elaboration and variety by Chris

Class Drawing

Pre-diorama Drawing

Diorama Drawing



The class drawing shows a colourful composition with various birds, ants, dog and also including a hunter, with birds nesting too. In pre-diorama drawing there are just isolated birds, horse and tree, while in diorama there is an oversized flying bird, beetle, shrew, rooster and 3 trees all drawn in iconic mode. This progression shows an overall reduction in variety and sense of habitat.

5.9 Additional data from interviews

During the interview, the children were asked to explain the content of their drawing. They were asked to mention influences on their choice of drawing and any other features they wished to include. Pupils were also encouraged to comment on features they felt were important to them. Some pupils (16%) were rather shy, quiet and uncommunicative and it was rather difficult to obtain answers and adequate information during the interview. Each answer or comment made by pupils was attached to the respective drawing as a memo (short note in Altas.ti). The following sub-sections contain the responses to each of the four tasks.

5.9.1 Drawing constraints

The physical environment of the diorama hall imposes limitations of space. It was a closed ended corridor with very little floor space for a group of children to sit down and draw with inadequate lighting for drawing comfortably. Instead, children were asked to draw as a class on floor mats in the adjacent bird hall.

I was interested to know whether and to what extent the children encountered difficulty in drawing and felt constrained by lack of time, since this may have affected their performance. In the case of the Class Task 21% said they had difficulty in drawing. Eleven pupils (19%) said they did not have enough time to finish or include other items. In the Pre-diorama Task, three pupils (5%) found difficulty, while one said he needed more time to draw. In the Diorama Task, 53% of pupils had difficulty to draw their preferred setting, while 20% required more time to finish their work.

I noted that, in the Class Task and Pre-diorama Task, various pupils drew features (mainly animals) and afterwards erased them. When asked why they had done that, they responded that they did not think that what they were drawing was 'good enough'. Children believe that there were expectations on the quality of their drawing and were not confident they were able to satisfy such expectations. It seemed evident that certain children drew few features because they lacked the confidence to produce a complete picture. The following data excerpts illustrate this point.

Three examples from interviews about the Class task drawings:

Example 1.

Researcher: *Would you have drawn any other animal or plant?*

Sephora: *Yes I would have drawn…*

Researcher: *What would you have drawn?*

Sephora: *A rooster and a hen and if I knew how, a whale and a dolphin too.*

Researcher: *Do you mean they were too hard to draw?*

Sephora: *Yes, I never drew them before and I can't draw them well…*

Researcher: *So you would have, if you could draw them properly…*

Sephora: *Yes certainly.*

Example 2.

Researcher: *Would you have drawn anything else?*

Catalina: *Yes I would have liked to draw other things…*

Researcher: *Why didn't you draw then?*

Catalina: *We have a tree with many leaves, but I could not fit it on the page.*

Research: *You mean there wasn't enough space on the paper?*

Catalina: *Yes, there was no space left…*

Researcher: *Where there any animals or plants you wished to draw?*

Catalina: *Some animals, but I don't know how to draw them.*

Researcher: *Could you mention them?*

Catalina: *I have a small and a big dog…. I would draw the bulldog and the small Chi Wawa and also some birds too.*

Example 3.

Researcher: *Are there any other animals you wanted to draw?*

Matthew: *…but it's difficult to draw them…*

Researcher: *Could you tell me more about this?*

Matthew: *Perhaps a horse, my dad drew one for me once, but it's too hard to do.*

Two examples from interviews about the Diorama task drawings:

Example 1.

Researcher: *Was this the first setting, the House Yard, you drew?*

Christian: *Yes, it's the yard…*

Researcher: *Why did you draw this one?*

Christian: *Because it's nice…*

Researcher: *So you liked this one best…*

Christian: *Not this one, but I thought it was the easiest to draw.*

Researcher: *Oh I see, so which one of the five did you like best?*

Christian: *…the one with the frogs in it…*

Researcher: *Oh you mean the Valley Floor, was that right?*

Christian: *Yes, that one…*

Example 2.

Researcher: *Why did you choose this setting out of the five?*

Aaron: *The one with the rocks was complicated, I was going to try the one having the boat but it wasn't turning out right because I had too many things to draw…*

Researcher: *Therefore, you thought this (house yard) was easier to draw, right?*

Aaron: *Yes*

Researcher: *But would you have liked to draw the others…*

Aaron: *Yes but they were too complicated*

Researcher: *Which one was your favourite then?*

Aaron: *The one with the boat (sand dune)… I started it, but saw it was too complicated, look here it shows…(boat drawn but erased)*

Researcher: *Ah, so you were drawing it but changed your mind…*

Aaron: *Yes, yes because I couldn't get it right.*

5.9.2 Influences on drawing

I was also interested to know what had influenced the children to draw what they had actually drawn. I asked them why they decided to draw that particular picture and from where they had obtained their ideas. The most frequent responses were as follows.

In the class task, nine pupils mentioned a garden or woods; two mentioned aquarium; ten mentioned TV, films, internet, books; four mentioned field or countryside; three mentioned holiday place and two mentioned pets or farm animals. In particular they mentioned the Mdina garden, which was in close vicinity to their hometown and San Anton gardens, which is the popular and public presidential palace garden. Some pupils also mentioned pet animals they have at home and wild animals they see around them in various everyday locations, such as their own or their neighbour's garden, the countryside, near the beach and a fresh water ponds in a field.

In the pre-diorama task, six pupils mentioned a garden or woods; four mentioned a field or countryside; three mentioned TV, films, internet, books; four mentioned a holiday place; eleven mentioned museum exhibits and two mentioned pets of farm animals. In this case, the museum specimens and gardens influenced most pupils, while in the class task most pupils were influenced by media sources and gardens. It would seem that the museum environment does have an effect on the way pupils perceive flora and fauna and what they drew in the bird hall. Pupils also mentioned their holidays in the United Kingdom and France, and the important natural places in Malta such as 'Buskett' gardens and 'Dingli Cliffs'. Others referred to their family's agricultural land since the school was located in a predominantly house northern area on the island.

5.9.3 Choice of diorama drawing

The pupils were asked to draw their favourite diorama after being allowed to view the five habitat settings for about ten minutes. During the interview at school, they were asked why they had chosen the diorama they drew and if it was really the one they liked best. If not, they were asked to indicate which one was their favourite and why they hadn't drawn it. A good majority, 67% (39) drew their favourite diorama; 22% (13) drew a diorama, which was not their favourite. Ten per cent (6) did not draw any diorama in spite of having a favourite. More than half the pupils (53%) expressed their difficulty while drawing a diorama and 20% said they needed more time to complete their drawing. Out of the 16 pupils that did not draw their favourite diorama or no diorama at all, 5 preferred the bastion, 3 preferred the sand dune, 3 the house yard, 2 preferred the valley floor, 1 the agrifield and 2 didn't like any. All the 16 pupils refrained from drawing their favourite or any diorama at all because they considered it too complicated and difficult to draw, so they settled for a diorama that was easier to draw.

5.9.4 Additional features that children wanted to draw

Another question I asked was whether there were any omitted features in the drawing they would have liked to have drawn, but chose not to. In the class task, pupils predominantly mentioned animals (85% of cases) giving 31 different species of animal, but only 4 plant types (9% of cases) and 4 physical features (6% of cases) were given. In the case of the pre-diorama task only three animals were mentioned, apparently the pupils did not feel they needed to add any further items to their drawings. In the diorama task, again they mostly mentioned animals (80% of cases) giving 10 different species found in the habitats, but far less plants (16% of cases) mentioning only 4 types and just one physical feature (4% of cases).

It was clear that most pupils prefer to draw an animal if they could, but did not because they thought it was too difficult or forgot about it when drawing. They mentioned a variety of animals, including domestic species, with the dog and cat being most frequently cited followed by bird and horse (see appendix). From the diorama animals, birds and the weasel were most frequently mentioned.

5.9.5 Other comments

A few drawings show ecological relationships, which the children explained during the interview. The relationships show included the following: mushrooms at base of a tree, an eagle predating a worm, a frog eating a fish at the beach, a parrot feeding hatched chicks, adult snake with two accompanying young and a bird opening the bi-valve shells of mussels to feed. One pupil drew a green wall and justified the colour as moss growing due to the dampness of the wall. Quite particular was the one where a butterfly was asking a robin where his mum was because he was lost, clearly indicating anthropomorphism.

The cultural aspect of the predominant tradition of bird hunting and trapping was also noted. A pupil commented that he accompanies his father whilst trapping, another drew a bird with blood stained plumage and yet another included a hunter shooting in a restricted area.

5.10 Observations and conversations in the diorama area

Pupils were observed and conversations recorded as pupils were observing and interacting with the dioramas. Pupils from the three participating classes entered the diorama room in groups of five and had eight to ten minutes viewing time. The salient findings that emerged were from the conversations are outlined as follow:

1. The rats, snails, birds and weasel seemed to have caught the pupil's attention the most. Other animals noted were the bats, frog and rabbit. It was rather surprising that very few talked about the rabbit even though it was quite in a prominent position in the field.

2. Some pupils did manage to notice the less conspicuous animals such as the shrew, gecko, owl, moth and lizard.
3. Animals in action, such as birds flying and snail crawling on the glass pane, attracted considerable attention.
4. Children talk about certain animals (as mentioned above), but in their drawings they show that they noticed, remembered and drew more animals than they talk about.
5. During the interviews pupils mentioned animals, they noticed and wanted to draw. All of these were heard in the conversations.

Quite interesting was how much interest the valley floor generated, especially due to the rats, flying bird and apparently 'moving' snail on pane, yet no one drew this diorama and only two pupils preferred to draw this instead of what they actually drew. Certain features in the diorama might attract attention, but this does not seem to be enough to encourage the pupils to draw it. As shown earlier, perceived difficulty, time limits and perhaps aesthetic value could be influencing their choice.

There were particular features in the dioramas that generated greater intergroup interest and conversation:

A. The snail on pane of glass of the Valley Floor diorama was one particular case. At least a couple of pupils in each group clearly commented on the snail on the pane. They though the snail was alive and moving. One student asked if the animals were real and another enquired about the snail:

Boy 1: "Was that snail alive?"

Boy 2: "Was it alive?"

One boy commented that the snail wasn't there earlier and his friends seem to concur.

Boy 3: "That wasn't there before we looked at it".

Two girls and one boy made comments of disgust about the snail on the pane of glass:

Girl 1: "Yak....that's disgusting".

Boy 1: "Uuqq...."

Girl 2: "I don't even want to touch the glass".

B. Pupils were scared of rats and made comments of disgust as soon as they notice them.

Girl 1: “Look there’s a rat”.

All move toward the bastion and immediate notice the rat in this setting too, one of them makes a disgusted comment on rat,

Girl 2: “Uuqq….that’s a rat”.

C. A new animal to the children seemed to be the weasel. The pupils did not know what the weasel was, those that commented found it unusual and asked what it was or mistook it for other species such as rat or tiger.

Girl 1: “Look, that is like a cheetah”.

Boy 2: “It looks more like a tiger, what is it?”

5.10.1 Social Behaviour in the diorama area

It was quite evident that the different groups exhibited different behaviours as they observed the dioramas. Pupils were split into ten groups, nine out of ten groups showed considerable enthusiasm and interest, just one group was rather distracted and disinterested and another was rather noisier than the rest. A pupil or two tend to lead the rest, calling the attention of their friends to particular objects and trying to influence choice of diorama to draw. In a way they impose their agenda on the rest of the group.

When they entered the diorama area, some pupils started to view the first setting (house yard), but others just walk past and proceed to view another setting (valley floor or bastion). Most pupils hovered from one diorama to another while deciding which one to draw and very few decided quickly what they would draw. Pupils discuss and ask each other what they would be drawing.

One female pupil was concerned she would forget some of the features in the diorama and so she asked the research (me) in a worried tone of voice: “How am I going to remember all those things”.

Two to three pupils from each group lingered behind to try and get another look before leaving to draw. They even asked the researcher if they could have another look or returned to the area to look again.

One male pupil asked, “Do we have to draw everything?” after his female friend told him they needed to do so. Clearly, the researcher did not require or ask for this. A few also asked the researcher if their drawing was fine, showing concern that theirs might be lacking the ‘expected’ quality. Others expressed difficulty and confusion on what to draw.

The next chapter 6 is a full discuss of the main findings; the mental models the pupils constructed and how they expressed the their models in terms of the biota and ecological relationships shown; how pupils interacted and interpreted the dioramas they viewed. The main feature of the discussion is the new interpretative model I present. A worked example is provided to illustrate how the model can be applied to data from a pupil in practice.

6 Discussion

6.1 Overview of the research

This research involves mixed ability 9 to 10 year old boys and girls attending a state primary school. The research was partly conducted in class where the children drew a place where they see animals and plants and partly at the National Museum of Natural History in Malta. Drawings done in class were regarded as an expression of the children's mental model of indigenous animals and plants in Malta. The children were at the museum to experience and learn about specimens held there, but particularly to observe the local habitat dioramas. They were asked to draw to show how they visualize the animals and plants as they occur in the diorama. The data collected was analysed to answer the main research question, which is:

> *How do Maltese children visualise animals and plants in natural history dioramas through the lens of their previous knowledge?*

Subsidiary questions:

1. What mental models (internal representation) of local animals and plants do school children hold and how are these expressed in drawing?
2. How far is the mental model modified by the novelty of the museum?
3. Which dioramas are preferred, what captures the children's attention and what role does culture play in this? Which species of animal and plant do children see most?
4. Which changes occur as a pupil progresses through drawing tasks?
5. Are dioramas appropriate as models in biological learning and for gaining of representational insight?

This thesis is an attempt to conceptualise habitat dioramas as a potential model for biological learning of local flora and fauna (Gilbert, 2005: 12, 2008: 6). Previous research has not considered how dioramas can enable the visualization of animals and plants, while little research has dealt with the educational value and role of habitat dioramas. Albeit the potential dioramas have to be a valuable tool in biological learning, these unique museum settings do not feature in any of the major museum texts by Black (2005), Falk and Dierking (2000), Hein (1998) and Paris (2002).

In the following sections the data are considered in the light of these research questions and how far they have been addressed. A constructivist perspective is taken since it views learning as the building and refining of mental models. Children construct mental models in ways that are specific and personal to them (Hooper-Greenhill, 2000: 118-119). Drawings in this study adequately show that mental models of different children are expressed in personal and distinct forms that vary from those of their peers. It is recognized that children draw the things that interest them and are important in their lives. In the latter part of this chapter, I propose an interpretative model that shows the relationship between the various elements that contribute to the building of mental models.

6.2 Mental models of animals and plants

The linguistic nature and history of the question set to task influences the response obtained. Barret, Beaumont and Jennett (1985) criticized Luquet and Piaget's stage theory on the basis of instructions, which the children received and how explicit the instructions given were.

Asking the children the question; *"Please, could you draw a place of wildlife?"* is different from asking; *"Please, could you draw what you think nature is?"* The term 'wildlife' evokes thoughts of animals, mainly visible, predatory species like lions and tigers while the term 'nature' evokes thoughts of trees and green pastures (Keliher, 1997: 241). In her study, Keliher (1997) found that all children included a tree in their drawings and mentioned trees, and birds when asked to define 'nature'. In the class and pre-diorama tasks, children were asked to draw 'animals and plants they see in Malta' and they drew more animals than plants (mainly birds, mammals and arthropods), but also wrote far more animals than plants. The ability to recall animals in preference to plants could be due to: a) greater knowledge about animals or b) the nature of the question asked.

The class drawings are an expression of their present mental model, of the flora and fauna of Malta. When observing and interpreting the dioramas, or any other museum exhibit, the visitor draws on his or her existent mental model. In other words, the visitor observes and interprets the dioramas through this conceptual lens. The novel museum environment was expected to have an effect on the mental model. Drawing at the museum confirmed this and for most children the mental model expressed did to a certain extent change, even if not for all in the same way. The mental model expressed in the drawings seems to be influenced by the place where children settle to create their drawings.

However, the Maltese children included far more animals in the webs done at the museum than they did in drawings, with much greater variety likewise dominated by birds and mammals. The occurrence of plants in the webs was slightly lower than that in drawings. Emulating the famous Ausubelian maxim (Bell 1993: 6), Freeman (cited in Krampen, 1991: 42) holds that "the child knows more than he draws". The proportions of animals, plants, and the other objects written in the webs (81%, 13% and <1% respectively) were almost identical to those given by Yorek, Sahin and Aydin (2009). Drawing is certainly a valid representational and research tool, but it may be limited in showing a child's comprehensive knowledge. I discuss this important issue in greater depth later in this chapter and in the concluding chapter.

In most of the drawings, a clear tendency toward iconic representation is noted. This can be attributed to cultural stereotypes and common iconography. General birds, ducks, cats, dogs, rats, fish, snakes, butterflies, snails and humans among others represented in typical iconic mode, mostly in the class and pre-diorama drawings. In most cases, animal species could only be identified after the particular pupils identified them as such in the interview.

The animals were generally represented in a similar form to that reported by Golomb (2004). Trees are seen in 'lolly pop' shape, with disproportionate trunks and flowers as 'sunflower', long stalk and prominent petals. Animals were almost only drawn in their standard sideways orientation, highlighting the distinctive features of the subject. Four legged animal drawings showed some degree of figural differentiation and display the right-angular directions seen in humans. For example; mammals were drawn in horizontal body displayed in side view, head in frontal view, four straight legs and an occasional tail. Fish were drawn as an oval with the usual sideways fish-mouth, one or two eyes and a tail. Birds were typically shown in aerial view with head, body, and tail aligned horizontally with wings extending vertically. This is an indication that the Maltese students were applying the principle of differentiation. A development noted was the change from iconic to more realistically represented animals and in some cases also plants. This shows a desire to capture the object and represent it was evident in those pupils that drew one or two animals in greater detail (Golomb, 2004).

Different children perceive and represent natural objects uniquely. This is also quite eloquently manifested in the masterpieces of famous artists like Van Gogh and Monet. Their attention to detail varies, with some children taking a more generalized view of the 'scene' depicting broad shapes and borders with little detail of plants and animals, but still using their own schematic graphics to represent them in some way. Others, albeit fewer, show greater detail as their attention is captured by the features of the organisms they observe. In this way, children's drawings became unique and personal, making generalization difficult while analyzing the drawings. Each drawing is unique and every child sees the diorama differently from their unique perspective, as influenced by culture and habitus. No drawing is a photocopy, but rather children select things that interest them influenced by what they already know. Drawings are children's personal creations and may be socio-culturally constructed in groups (a class) as they interact with each other and the museum setting.

At the museum, pupils constructed their own mental model as they viewed the dioramas in groups, i.e. in a social context and within cultural norms held. In this case, the local habitat dioramas are the physical context and which raises a question? Are dioramas museum settings exhibiting museum objects or are they human constructs containing biological specimens (naturally occurring animals and plants, not artefacts)? Mental models were expressed and mediated through the cultural tool of drawing. The cultural aspect plays an important role here. Drawing, as a representational mode, differs from speech and writing in that it affords its own semiotic logic based on space and focuses on the salient objects encounter rather than the sequence of events (Kress, 2010: 93).

The following section addresses the questions: what mental models of local animals and plants do school children hold and which species of plants and animals do children see most?

6.2.1 Species of animals children see most

The results from this research point toward a more comprehensive idea of what qualifies as an 'animal' for Maltese 9 years olds than reported in literature (Bell, 1981: 56). Children in general hold varying understandings of the term 'animal' and this may be attributed to the confusion between the scientific and common meaning of the word 'animal' (Bell, 1981: 56; Tunnicliffe et al., 2008: 217). The general archetype animal of most pupils is the large terrestrial, four-legged vertebrate, mostly mammal species (e.g. cow, cat, lion, elephant) and animals found at home as pets, on a farm or in the jungle.

The class drawings presented the subordinate groups (taxon) *amphibian, bird, cnidarian, crustacean, fish, insect, mammal, mollusc* and *reptile*, while the museum drawings presented the subordinate groups *bird, echinoderm, fish, insect, mammal, mollusc* and *reptile*. Birds (37%), mammals (24%), arthropods (16%) and fish (13%) were the animals mainly drawn in class, while birds (60%), arthropods (18%) and mammals (13%) were mainly drawn at the museum. A comparative study among six European and American countries found the following order of frequency: mammals, birds, invertebrate, amphibians, reptiles and fish (Patrick et al. 2013). Other studies reported similar findings (Chen and Ku, 1998; Trowbridge and Mintzes, 1985, 1988; Tunnicliffe *et al.*, 2008; Yen *et al.*, 2007). Huxham et al.'s (2006) findings differ from these in that children of all ages and both sexes scored better with mammals than with birds and arthropods. In this study, differences in number of species was not so striking; class drawings yielded 15 different species of mammals, 11 species of bird, 5 species of arthropods, while museum drawings yielded 16 different species of bird, 10 species of mammals, 4 species of arthropods. However, the particular species (mainly bird and mammal) drawn in class differed appreciably from those drawn at the museum. At the museum there was a clear shift in favour of birds as opposed to mammals in the class drawings. The novelty-factor of the field trip (Falk et al, 1978) must have, to a certain degree, influenced what the children drew at the museum. The following examples relate to the question: *How far is the mental model modified by the novelty of the museum?*

Figure 6-1. Drawing sample by Christian

Class Drawing	Pre-diorama Drawing
	
Place: not specified	Place: garden
Animals: 2 types of birds, birds in nest, ants, dog	Animals: horse, 2 pigeons
Plants: 2 types of tree, flower	Plants: tree

Christian (9yrs) in class produced a colourful scene showing many birds, some of them in flight, crawling up a tree (r.visualization.s), a dog, two trees and a flower. In the center of the picture is an old man with a dog crossing bridge with water flowing underneath. Right immediately behind is a hunter shooting at a bird, which is seen hit. This picture has many aspects: colourful narrative, birds in motion as a property of being 'animal', ecological relations, human effect on wildlife, and sun in the typical Maltese blue clear sky. The pre-diorama picture does not show the graphical richness of the class drawing with just one mammal and 2 birds, but the sun still features.

Figure 6-2. Drawing sample by Mark.

Class Drawing	Pre-diorama Drawing
	
Place: not specified	Place: field
Animals: eagle, budgerigar, adult parrot feeding hatching young in nest, dog, cat, butterfly out of chrysalis and caterpillar.	Animals: vulture and eagle
Plants: tree, moss and grass.	Plants: none

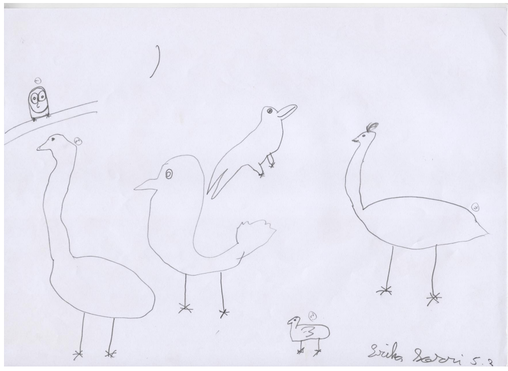
Mark (9yrs) also produced a very colourful scene with four birds, an eagle, two parrots and a budgerigar; two mammals, dog and cat; and two invertebrates; butterfly and caterpillar. The depiction of the parrot shows a feeding and caring relationship, while the butterfly shows reproduction/metamorphosis. Aspects of this picture are: colourful narrative, birds in flight, ecological relations, reproduction and again the sun but lacking sky. The pre-diorama picture just shows two predatory birds exhibited there and even the sun is absent.

Figure 6-3. Drawing sample by Erica.

Class Drawing

Place: Public Garden (presidential residence)
Animals: ducks in pond, flying birds, bird with nest holding egg and fish in pond.
Plants: 2 species of tree, tulip, wild plant.

Pre-diorama Drawing



Place: not specified
Animals: Owl on tree, duck, flamingo, ostrich and two unidentified birds.
Plants: none

Erika (9yrs) produced an artistic picture, with iconic aspects such as the 'V' shaped birds, but also different representation for ducks, oval fish and lolly pop trees. Again one notes a preference for birds and no mammals, with reproductive features of the nest and eggs. Her pre-diorama picture reinforces preference for birds, but includes species found in the bird hall, drawn as isolated objects with no colour.

Figure 6-4. Drawing samples by Lenise, Dale, Andrew and Gerald.

Class Drawing	Pre-diorama Drawing
	
	
	
	

Lenise (9yrs) drew two very similar drawings in composition and iconic forms used despite the different context. Dale's (9yrs) drawings also show many similar iconic forms, but with slight differences in composition e.g. sun, cat, glasshouse and butterfly. Andrew's drawings also show similar forms, but with more items in the class drawing, while Gerald's drawings show a pet shop/garden center with some difference in bird iconic mode. Although generally there are differences in the class and pre-diorama drawings, some children produced very similar representations. Some individuals do appear to hold constant mental images even when exposed to novel environments and varying stimuli.

Which species of animal and plant children represent most is also influenced by culture. Children's drawings make explicit their ideas and attitudes that are not free from stereotypes and simplifications that exist in culture (Moussouri, 1997). The data of this research broadly support the strong presence of birds in Maltese culture. The natural history museum also reflects this greater importance to birds by affording its largest hall to them. In one of the few research studies done locally, 94% of year 5 and year 6 primary students selected birds as forming part of the environment (Buttigieg, 2001: 38). Animals mentioned are particular to the country suggesting that children gain knowledge about local animals from daily observations (Byrne et al., 2011). The horse is the largest mammal in Malta and pigeons are commonly reared birds, while the sparrow is the most common wild bird. A variety of migratory birds, such as the eagle, visit the island, but these are very rarely encountered. On the other hand, domestic species such as cats, dogs, cows and horses are common in urban and suburban areas. So the predominance of birds is somewhat surprising, but could be due to the almost total lack of wild mammals living in Malta and those still in existence are rare and relatively inconspicuous such as the wild hare, weasel and shrew. However, this is less surprising if one considers that birds are culturally important due to the ever controversial sporting traditions of hunting and trapping that raise passionate arguments between bird conservationist groups and the hunting lobby. The organisation Birdlife (Malta) is quite active and regularly promotes bird conservation and protection in schools. On the opposite front, the hunting lobby is politically quite influential. The discovery of a shot protected species immediately hits the news and holds the agenda for the week. Children may at home have stuffed birds of prey or may have seen a specimen or two at someone else's house. A bird is also a common pet in many Maltese homes.

This research also shows that arthropods such as ant, bee, butterfly, ladybird and spider ranked more highly in frequency among Maltese children. Bartoszeck et al. (2009) found that the bee, cockroach, beetle, ant, cricket and dragon-fly were most popular with children from northwestern Brazil. Invertebrates such as the snail, butterfly and spider are the least common species to be considered as animals (Bell, 1981; Chen and Ku, 1998; Trowbridge and Mintzes, 1988; Tunnicliffe *et al.*, 2008).

Research studies on students' views about animals indicate that they were mostly interested in vertebrates, pets (cats, dogs, horses) and exotic species (e.g. dolphins, tigers, lions) (Braund, 1991, 1998; Lindermann-Matthies, 2005). The mammals drawn in this research were mostly endemic or domesticated species (cat, cow, dog, donkey, hamster, horse, bat, rabbit, rat) and far less exotic species (elephant, leopard, lion, tiger, monkey, kangaroo, squirrel). Similarly, other research showed that American children were more interested in endemic animals compared to national or international animals (Patrick and Tunnicliffe, 2011: 639; Trowbridge and Mintzes, 1985, 1988). However, Tunnicliffe et al. (2008) in another study with young Maltese children found that they mostly mentioned exotic non-endemic animals such as tiger, lion, crocodile and giraffe. Such a finding is in accordance with what the children in this research listed mostly in their webs, that is, non-endemic mammals such as whale, cheetah, zebra, koala and deer. In their webs, children wrote names of animals and it is known that writing affords a different semiotic logic to drawing (Kress, 2010: 93). Therefore, only the web data seems to confirm what previous research found that students from Malta, New Zealand, Taiwan and the UK have tended to name exotic, non-endemic species found in zoos such as the giraffe, elephant, and tiger (Bell, 1981; Chen and Ku, 1998; Patrick and Tunnicliffe, 2011; Tunnicliffe *et al.*, 2008; Yen *et al.*, 2007).

In accordance with another study, Maltese children very rarely drew aquatic/semi-aquatic mammals such as dolphins, whales and seals (Tunnicliffe *et al.*, 2008). None of these species are present in Malta and children would have only seen them in the media or at a zoo/water park while visiting a foreign country. Likewise, humans featured at a relatively low frequency (Yen *et al.*, 2007). Drawings (13%) did however include fish, although one would have expected a higher frequency given that Malta is a small island and the sea is only a few kilometres away.

6.2.2 Species of plants children see most

Young Maltese children, similar to English and New Zealanders, possess limited knowledge about plants (Gatt et al., 2007: 120). This research, like that by Bell (1981), shows that primary children from different cultures have similar ideas about plants. In both class and museum, children drew far fewer plants than animals with far less variety too and mainly seeded types. In class drawings the following plants were noted: moss, palm, tulip, reed, sunflower, daffodil, apple, olive, orange, peach and pine tree, compared with apple, cherry, pine, rose and sunflower in museum drawings. When they couldn't give a particular exemplar, children referred to the vegetative specimen as simply 'plant' (Bell, 1981). Gatt et al. (2007) reported that few Maltese children were able to mention more than three examples of plants and most frequently gave the superordinate categories 'flower', 'tree' or 'plant' and a few mentioned 'rose' and 'sunflower' (pg.119). The findings seem to strengthen the view that plants are of no immediate importance to children (Bowker, 2007:91 and Johnson, 2004:79) that seem to have what has been referred to as '*plant* blindness' (Wandersee and Schussler, 2001). However, Buttigieg (2001) reports that Maltese year 5 and 6 pupils chose flowers (98%) and trees (97%) as forming part of the environment (pg.38). To primary school groups plant means a flowering plant, a cultivated plant or any other herbaceous organism that cannot be otherwise named and interpret them using their everyday knowledge (Tunnicliffe, 2000). Similarly to what was found by Gatt *et al.*, (2007) in one of the few studies in Malta, most commonly mentioned trees in this research were the orange, the lemon and the apple tree. Children are familiar with orange and lemon trees since these are commonly present in house back yards and public gardens. It is however harder to justify the presence of apple trees in drawings since these are far less common in Malta. Gatt *et al.* (2007) reported that children also mentioned pear, banana, peach, grape and pomegranate, while in this research they also mentioned palm, olive, peach, pine and cherry trees.

Children in England were more likely to name Bryophytes and seedless vascular plants than children in the USA. This could be an indication that the local community plays an important part in what children know about plants. Children in both countries name agriculturally produced plants more than any other group and children mostly see these at home, in a garden or in a yard. Such differences seem to be culturally influenced (Patrick and Tunnicliffe, 2011: 638). In Malta in this study there was a strong cultural feature in that the sun was present in 60% class and 44% museum drawings, which confirms findings of another study where 55% of pupils selected the sun as one of 5 most common features that form part of the environment (Buttigieg, 2001: 38).

In both class and at the museum, just before viewing dioramas (pre-diorama), most pupils were capable of producing a complete picture showing a recognisable place they were familiar with such as a garden, valley, seaside, glasshouse or shop in class and woods, field, farm, park and garden at the museum. In class, 86% of drawings, compared with 67% at the museum, showed organisms in context and 74% compared with 53% at the museum, showed a habitat. At the museum, however, more children drew individual drawings of objects represented in absolute isolation with no context. Tunnicliffe et al. (2007) reported similar findings in a study of students drawing pigeons. Graphically, 75% of drawings done in class were in colour (37% at museum), while 25% were in black and white (63% in museum). Older children are expected to commit more to visual realism, complexity and colour (Cox, 2005: 239; Piaget and Inhelder, 1967; Tunnicliffe et al., 2007: 17). Children mostly used the iconic mode to represent animals and plants in their class and pre-diorama drawing which is indicative of intellectual realism. The Maltese children in this research show a greater degree of visual realism in the their diorama drawings, however the iconic mode remains prevalent.

The context (class or museum) where drawings were done is a major factor in the use or otherwise of colour. The comforting and familiar environment of the classroom is conducive toward good compositional and artistic performance. Drawing and painting during art lessons is done in class, albeit art being a peripheral area in the curricular.

The museum was a novel space and the children could only draw on the floor using a clipboard. Few drawings showed anthropomorphic features. In class drawings of human features were present in 63% of drawings (33% in museum), most of which were man made objects such as a boat, rubble wall, house, glasshouse, road, aquarium, aeroplane, barn and tools. The pre-diorama task produced fewer codes than the class task, which was rather surprising. However, this was the purpose of the pre-diorama task: to see if children would produce any significant changes in type and quality of the museum drawing when asked to draw a place with animals and plants.

6.3 Interacting with the dioramas

Information in the brain is processed on pre-existing 'schemata' or mental knowledge maps. New knowledge can either be integrated into existing schemata, as Piaget termed it 'assimilation', or the schemata are reorganised to adapt the new information or 'accommodation' (Smidt, 2011). Each person processes new matter uniquely as individuals according to their mental knowledge maps influenced by their cultural and biographical experiences.

Most of the pupils (90%) managed to draw a representation of the content of a diorama, while only two did not have a favourite, which indicates that pupils were positively influenced by the exhibits. The diorama as the object created the situational interest for the visit. Dioramas enhance situational interest when they induce emotional reactions and offer reference to allow different visitors to relate to prior experiences to the object observed. Annette Scheersoi (2009) examined drawings constructed at dioramas to find out what 8 year olds select and find most relevant. Situational interest arises from: recognition of familiar, young or big animals and unexpected objects (Scheersoi, 2009: 12).

A familiar place with children is the internal yard of traditional Maltese houses and this could explain why the House Yard featured most frequently (39%) in the drawings. Children noticed, as gauged through the content in their drawing, most features (22) in the rural yard diorama. The construction of meaning is partly shaped by prior knowledge and experience, and by how the past is related to the present (Hooper-Greenhill, 2000: 118-119). However, the Agrifield and the Sand Dune were also commonly selected and represent two sites frequently encountered in the countryside and at the sea-side. This is another indication that interest arises from recognition of the familiar and what is already known (Hein, 1999; Tunnicliffe, 2009; Scheersoi, 2009). It must be noted that choice of diorama was also affected by actual or perceived difficulty in drawing. The question of discrepancy between (cognitive) competence and (drawing) performance is treated in a forthcoming section (Hopperstad, 2010: 432; Piaget and Inhelder, 1967: 71;). Other than the limits of our mental representations, an array of other factors constrain our reconstruction such as nature of the task, immediate context, our arousal level and mood, which may all effect how we build meaning from our incomplete knowledge structures.

The general trend showing that animals are the most noticed and plants appreciably less was observed in each diorama drawing. A good number (75%) of drawings featured a least one plant, but the total number of plants (14%) was half that of animals (32%). Human artefacts (man made structures) seem to be more important to children than plants.

The apparent disregard of child for plants has been previously reported in literature. Wandersee and Schussler (2001) coined the term *plant blindness* and argued that two possible indications of this might be: a) the idea of plants as just the backdrop for animals and b) failing to notice plants in the environment. Plants in the local habitat dioramas at the NHM in Malta are located in prominent positions and not just serving as a background for animals. Motion was most frequently associated with the concept life. Studies done at different ages showed that the main reason for students' interest in animals rather than plants was movement (Kinchin, 1999; Wandersee, 1986). So it would seem that children perceive the sessile nature of plants as lifelessness.

An interesting observation was that almost half (47%) the drawings contained a feature not present in the dioramas, showing an evident tendency to insert organisms or objects from outside the diorama. Pupils construct their own mental model as they view the dioramas, their prior knowledge influencing this process. Some of the students express a mental model that is in part a composite of what they already hold in their memory and what they assimilate from observing the diorama. In this way they are reconciling what they already know with the 'new'. Litson and Tunnicliffe (2002) reported similar findings with children drawing apples from life and memory. Actual first-hand observations were made, but the presence of features not seen suggests that children draw from their existing mental model even when making a drawing from real life. Results in this thesis support the view that intellectual realism and visual realism, as explained in theories of Luquet (1927) and Piaget (1969) may coexist. Drawing ability is considered to be a more fluid process, where the child progresses through the drawing development stages, but can easily slip back to a previous stage if they found it useful to do so (Symington, 1981: 45; Krampen, 1991: 38; Cox, 2005: 73). Results also confirm Bruner's belief that children are capable of both ways of representation at any time and also Gardner's assertion that people have different levels of simultaneous development in varying domains or multiple intelligences (Robson, 2006: 16, 33).

Also, a pupil does not simply retrieve a holistic mental replica of knowledge held in memory. Instead, the student retrieves elements of the partial representation he/she has stored of the object or concept (Rapp and Kurby, 2008). It is not necessary to represent all that is observed, known and remembered. A person selects what is of immediate interest where features are not shown in their entirety (Mavers, 2009: 265; Cox, 2005: 75). What ultimately fills up the blank sheet is a representation of objects previously encountered and others from the observed setting.

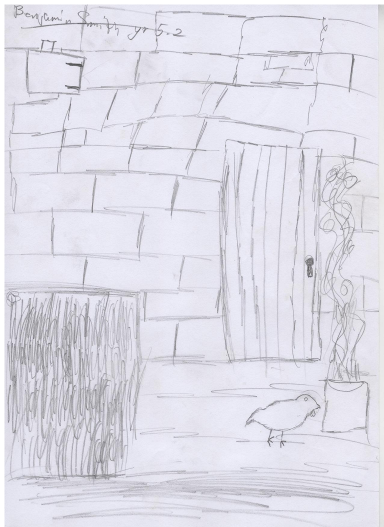
Apart from content, the drawings were also analyzed in relation to diorama composition. Most drawings contained a low number of animals and plants present in the diorama. Few children included more than half the animals and plants in the diorama, while they tend to draw more of the physical features of the setting. Children missed the less conspicuous biota or omitted what they could not draw. There is a tendency to notice the larger animals or the unusual or unexpected.

Notably, most drawings (70%) display all items in the same place as they occur in the diorama indicating an accurate spatial perception (high acuity). The viewing of the dioramas acts as a trigger for children to assemble their related memories about the topic and compile a personal representation of the topic. In drawing, children recorded selective features that they find most relevant.

These are generally connected with their personal experiences of everyday observations of animals around, media representations and narratives.

There is also an aspect of scale and perspective in drawing. Very few class and pre-diorama drawings show a sense of perspective and animals drawn in proportion to the other items in the drawing. However, children (40%) show a greater sense of perspective and depth through their diorama drawings. Evidence points to an association between producing a diorama drawing and increased sense of perspective.

Figure 6-5. Drawings by Benjamin

<table>
<tr><td colspan="2">Class Drawing
</td></tr>
<tr><td>Pre-diorama Drawing
</td><td>Diorama Drawing
</td></tr>
</table>

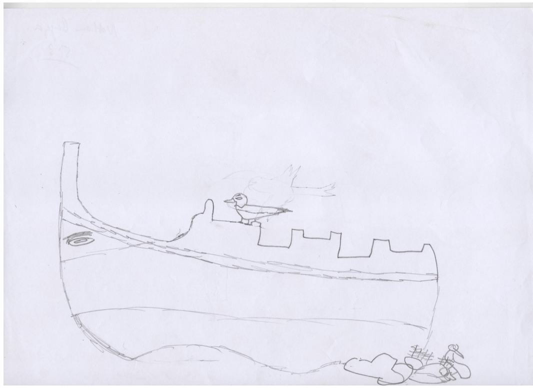
Various pupils justified the absence of further organisms in their drawing due to difficulty or insufficient time, stating that they would have liked to draw more. Limitations in drawing ability, also noted by Hopperstand (2010), Cox (1992), and Anning and Ring (2004), were evident in sets of drawings showing just an animal or two drawn in very basic form. However, some pupils preferred to concentrate on drawing one animal in greater detail instead of drawing many items, which are equally time consuming and require commitment. The drawings below clearly exemplify this.

Figure 6-6. Drawings by Nathan

Class Drawing

Pre-diorama Drawing

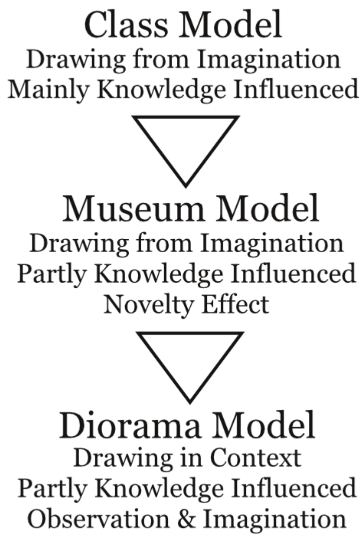
Diorama Drawing



6.4 Interpreting the diorama

Although individual drawings by children tend to vary appreciably, studying drawings by the same child may reveal idiosyncrasies that illuminate the influences on how the animals and plants in the dioramas were interpreted and visualised. In class, the mental model expressed in drawing is mainly from imagination and basically influenced by knowledge held by the pupil at that moment. At this stage, children mainly draw in the iconic mode being able to make mental images of objects and do not need to experience the object physically. Bruner (1966) termed this the *Iconic Stage,* where information is stored visually in the form of images (a mental picture in the mind's eye). The child uses an array of schemas possessed to produce a more artistic and less faithful picture if the object is known, but would copy slavishly if the object is unknown trying to produce a more faithful drawing. Children (5-8yr olds) produce different drawings when they draw from imagination compared to when they copy an object (Gardner, 1980: 164).

Figure 6-7. Progression of mental model from Class to Diorama.



At the museum, children mainly drew from imagination, but also party influenced by previous knowledge and now also the novelty factor of the unfamiliar museum. Iconic mode is still predominant at this point. The evidence from class and pre-diorama drawings (museum) are indicative of *Intellectual Realism* as coined by Luquet and Piaget. The mental model is still mainly formed by 'what the child knows.' The diorama drawings are now the result of observation and also in some cases imagination. Drawings are still mainly iconic, but they increasingly show organisms in context. Students show a greater degree of *Visual Realism* here, drawing things they 'see' and representing these as they occur. However, most students still resort to their iconic forms to show what they saw thus operating from *Intellectual Realism*. Arnheim (1974) suggested that a child will draw an object which will show the defining features (as the child see's them) in the simplest way for the child to be able to draw them within a piece of paper (2D space).

This would suggest that the *Representational Stage* has been reached by most pupils, that is, when the child makes basic and generalised representations of organisms. The human figure consists of a round form, inner shapes that become the eyes and arms as two lines radiating from the circle. The child draws just a "dog" rather than his or her dog (Garden, 1980; Kellogg, 1970;

Lowenfeld, 1963, 1964; Striker, 2001). Apart from the principle of differentiation that applies broadly across a wide range of tasks and subject matter, a second principle becomes evident. This is the desire to create a likeness to the object. This desire to capture the object and represent it truthfully guides the direction the differentiation of form takes.

Commonalities through the sets of drawings by individual children indicate that characteristics in the drawings done before viewing the diorama are reflected in the diorama drawing too (similar number of birds and iconic mode). It would seem that the existent mental model was being used to interpret the diorama and then to select features from the diorama that subsequently were included in the picture. Each pupil draws quite distinctly and many times as unique "as are fingerprints" (Golomb, 2004: 357), but the representational detail of organisms enables a degree of classification too.

When they were asked to draw in school and pre-diorama, children did so from imagination and previous knowledge while it was increasingly from observation during the diorama task. Most class and pre-diorama drawings were complete constructions of scenes created in the minds of the children, such as gardens, forests and beaches. The diorama drawings were done from looking at particular settings, and so show a personalised representation of the preferred setting. This left less room for creativity, and rather drawings showing varying degrees of resemblance to the dioramas. However, almost all diorama drawings show modifications from the actual, where the pupils give their personal 'touch' to the drawing by selecting items to represent from the setting and adding others from their memories.

Children were cued into noticing by the instructions given to draw, which is a form of scaffolding as Bruner explained it. More knowledgeable peers aid in the discovery and interpretation of animals and plants in the diorama. Viewing of new animals and plants in the dioramas has the potential to result in a form of cognitive imbalance as theorised by Piaget. Children accommodate new understanding into their existing knowledge, but could this is appreciably enhanced if assisted by a more knowledgeable other (Jensen, 2011).

6.5 An interpretative model

Sociocultural theory is linked to activity theory, but in the latter emphasis is on the activity itself, while sociocultural theory emphasizes mediation (Smidt, 2009: 90). To understand how children make meaning with drawings we need to search for the interests that drive them, as these, according to Kress (1997, p. 19), are always reflected in the drawing.

After considering existing models namely: Activity Systems (Leont'ev, Engeström, 1999), Contextual Learning Model (Falk and Dierking, 2000), Acuity Model (Patrick, 2006) and Model Based Learning (Buckley and Boulter, 2000), I consider *Activity System* (section 3.4.1) to be most appropriate and so I base my model on it, with the inclusion of additional features as suggested by empirical evidence from my research. Figure 6-8 below shows the Interpretation model, which presents six interrelated factors as explained in the table 6-1. Focus, Artefact, Group and Subject emerge from Activity theory, while Culture, Previous Knowledge, Mental Model and Expressed Model emerge from data. My endeavour is to propose this model that may be used to interpret museum objects or artefacts and particularly in this case the habitat dioramas.

Figure 6-8. Interpretation Model for cultural tools.

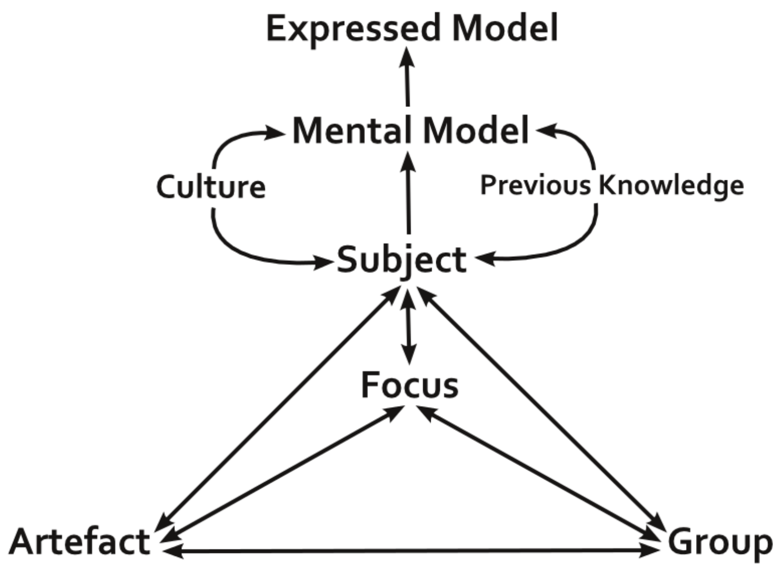


Table 6-1. Interpretation Model terms defined

Subject	The person observing the diorama, i.e. student or visitor.
Artefact	The mediating tool; a diorama, picture, 3D model or other media forms.
Focus	The idea, topic or location represented by the artefact and of interest to the subject and/or group, such as 'habitat'.
Group	The group of people i.e. friend or family, with whom the subject experiences the artefact.
Mental model	The personal representation of the artefact or focus held in the subject's mind.
Expressed model	The external representation of the mental model.
Culture	The sociocultural imprint of the family, country and society.
Previous knowledge	What the subject already knows about the focus.

In the Activity Systems the *object* is analogous to the *focus* here, but here it refers to a habitat or a natural object rather than objectiveness of the reality, which for Leont'ev has social and cultural properties. For the "person-object-relation" (POI) theory the creation of interest needs a situation-specific interaction between person and the object (Deci and Ryan, 2002). The *focus* generates situational interest that is important for learning particularly in non-formal learning settings (Scheersoi, 2009: 10). Situational interest emerges from the viewing of the diorama, but individual interest is also required and this resides within the individual or the *subject*.

Subject has the same meaning or the person engaged with the exhibit. Do the visitors see the dioramas as representations of a natural setting? What is obvious to the expert might not be so to the novice. Primary school children are normally novices to learning from visualizations. There is also the risk of dual representation; novices may focus attention on the object itself rather than the intended meaning.

Community is here the *group* or all those involved in interacting with artefact. In the sociocultural context learning occurs while experiencing a museum artefact with other pupils. Experiences initially with others on the inter-mental plane then individually experiences are internalized on the intra-mental plane.

Mediating artefact is here the *artefact* being observed such as a museum exhibit, model or other medium that mediates understanding of the *focus*. The *artefact* generates interest in the *focus* and interest is affected by experiences and personal history (Falk & Dierking, 2000). Interest facilitates 'new' knowledge about the *focus* constructed by interacting with the *artefact*. Learners use models to assimilate 'prior' knowledge and incorporate it into 'new' information about the instance (the *focus* here) into the mental model of the situation (Buckley and Boulter, 2000). The mental model is reinforced and routinely used if judged to be adequate or rejected or revised if considered inadequate. A diorama as a museum object may serve as a biological model. Museum objects are devoid of meaning without the agency of museum visitors. However, understanding objects is complicated since the categories of meaning are more vague with objects than with texts. Every person interacts uniquely with a museum object to form a unique mental map depending on prior cultural and biographical experiences (Hooper-Greenhill, 2000: 114).

Previous Knowledge: In informal settings learners readily make associations between what is already known and new knowledge. Museums allow meaning making by connecting with what is already known and compare the unfamiliar with the new (Hein, 1999: 76; Hooper-Greenhill, 2000: 118-119). Representation frequently tries to make sense of previous experience and it is a dynamic, constructive act that actually shapes the experience itself (Matthews, 2003: 21). Held knowledge about animals and plants in this thesis is expressed in the class and pre-diorama drawings, webs and additional information given during the interviews.

Culture: The social constructivist would consider the role of culture and of peers as children interact in groups. Wertsch (1991) does not consider the person as a decontextualized individual, but reasoning is conceived to be an inherently social and cultural process of meaning making. It is interesting to see how children's drawings make explicit their beliefs and attitudes, which are not free from stereotypes and simplifications that exist within the culture of the school (Moussouri, 1997: 41-46). Drawing as a mode that is socially shaped and culturally given resource for meaning making. Drawings from different societies and regions of the world do not support the notion of a universally valid, culture-free instrument for cognitive assessment (Golomb, 2004: 343). It is well recognized that children draw the things that interest them and are important in their lives, but this varies in different cultures.

Mental Model: As each person has their own mental maps of knowledge depending on their prior cultural and biographical experiences, each person will process new matter in ways that are specific to them as individuals (Hooper-Greenhill, 2000: 118-119). The child's personal knowledge of a phenomenon or main features of an object are held in his or her mental model and when asked to draw, the child does so from the internal model (Reiss and Tunnicliffe, 1999: 142 and Cox, 1992: 88-91).

6.5.1 The model applied to data from one child

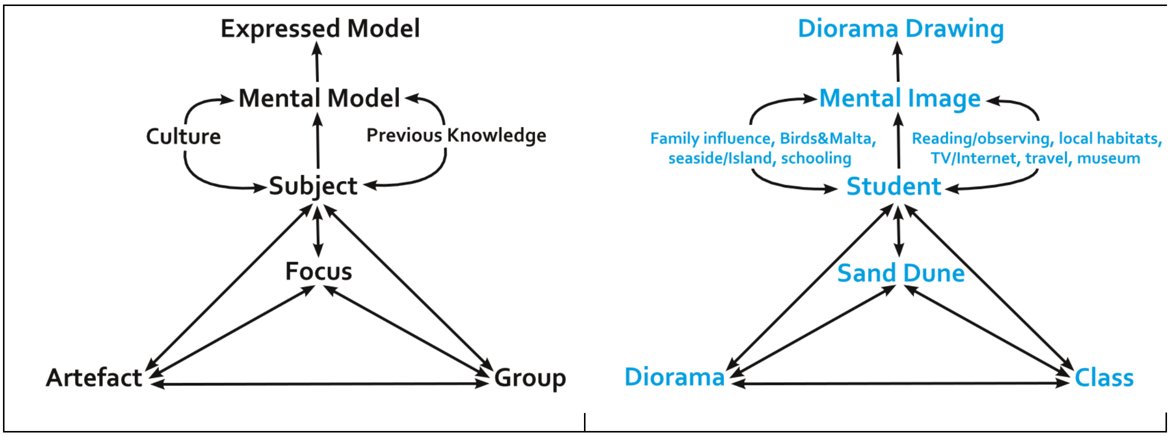
The *subject* is in this case was the pupil observing the diorama, namely Jeremy a nine-year-old boy in the fifth year of primary school. The *group* was his class and particularly the group of five pupils he was experiencing the diorama with. The *artefact* in this case was the Sand Dune diorama preferred by this pupil, as confirmed by himself during the interview. So, we have a static 3D artefact with various birds, a typical sand dune plant and a very prominent traditional Maltese boat resting on a bed of sand. There was no pained background here, since the colourful boat occupies most of the space. The pupil observes the diorama, which acts as the mediating tool to aid in the interpreting and understanding of the *focus* or the Sand Dune habitat represented by it. He does this in the company of his colleagues, which may influence the way he 'sees' the diorama and what he notices or not. The role of the more knowledgeable peer may come into play here. However, it is difficult to determine to what extent this occurs and what the actual influences would be.

The observation of the Sand Dune diorama (*artefact*) results in the creation of a mental model, which is than expressed as a drawing. This representation is a likeness or simulation of the museum object. In learning we often use an external representation (*artefact*=diorama) to build an internal representation, held in the viewer's mind. However, unlike external representations, there is no tangible evidence and we cannot manipulate mental representations. Very often, we must convert our mental representations into external presentations. The child's personal knowledge of a phenomenon or main features of an object are held in his or her mental model and when asked to draw, the child does so from the internal model (Cox, 1992: 88-91; Reiss and Tunnicliffe, 1999: 142). The child's representation of the diorama may be seen in the following figure.

Figure 6-9. Jeremy's Sand Dune representation.

There are some similarities, such as the bird on the boat, the flying bird, the two brown birds on the left and the bird on the rock on the right. However, there are differences too, such as the bird opening the mollusc shell (central), the blue background, no reeds drawn and notably the boat facing the other way. These differences are the evidence of *previous knowledge* merging with what was perceived from the diorama. During the interview, Jeremy expressed his interest in wildlife, especially sea life and sea birds. He read about the bird opening mollusc shells and wanted to add seaweed too. The class and pre-diorama also show evidence of prior knowledge from observation or local habitats and media sources. The *cultural* influence is noted in the inclusion of blue 'sky' background and the rather standard way the birds were represented, that is, in side view with beaks, both legs, eyes and in aerial view. Golomb's (2004) findings on graphical representation and central positioning of animals, and balance and linking of the different features in composition on the drawing are reflected in Jeremy's drawing. The choice of diorama was influenced by the child being an island inhabitant and so well acquainted with the seaside habitats.

Figure 6-10. Applying the Interpretative Model.



The web done by Jeremy includes a variety of organisms, which shows that he possessed a wider knowledge of animal species than he included in his drawings. Almost all of the species mentioned were non-endemic and mostly vertebrates.

The model could also be applied to the class and pre-diorama drawings. The pupils (*subject*) also did these in a *group* in class or at the museum. In this case the mediating tools (*artefact*) were books, pictures, museum exhibits and multimedia. The *focus* in this case was the local cliff formations (at Dingli) with predatory birds (seen at the museum) inhabiting and nesting the cliffs.

Figure 6-11. Jeremy's local cliff and predatory bird representation.

The above drawing is the *expressed model* of the his *mental model* constructed by knowledge gained from books, media, travel and direct observation of local habitats and museum exhibits. The pupil used this *previous knowledge* to create a mental image, which was subsequently expressed in the drawing above.

Therefore, the Interpretative Model can potentially be applied to different learning situations in science and other areas that employ the use of various types of mediating tools, in formal, non-formal and informal settings.

Although the model is undoubtedly useful it does have limitations. First of all it assumes that the subject uses the artefact affectively as a mediating too, but this might not be the case. It is not certain that the *artefact* would actually help interpret and understand the *focus*, the subject could effectively concentrate on specific items in the setting ignoring the bigger picture. This is not to say that no learning occurs, but not as might be intended by the museum or the learning provider. There might be features that distract the subject or capture his/her attention for aesthetic reasons only. The degree or quality of interaction between the *subject* and *group* may be difficult to determine.

The *mental model* is very personal and varies from person to person. Being so intangible, one can never be certain what mental image a person really holds or how this is modified and developed by the learning experience. On the other hand the *expressed model* is almost never a 'true' replica of the *mental model*. The *expressed model,* such as a drawing, is normally a selection of what really interest that person. It is usually a mixture of what is being observed and previously acquired images from earlier learning. In my model, I also include the effect of *culture* and *previous knowledge* on the subject and his/her *mental model*. These are both long-term factors, which influence the way persons learn, acquire new knowledge and build *mental models*. However, it is difficult to assess the effect these have on the learner and his *mental model*.

6.6 The Diorama: biological model for learning?

One of the subsidiary research questions was: Are dioramas appropriate as models in biological learning and for gaining of representational insight?
Dioramas have been described as valuable resources for learning in biology (Paddon, 2009: 26; Quinn, 2006:10; Stern, 2009:15; Tunnicliffe, 2005:15, 2007:7, 2009:20) that enable visitors to bring their interests to the exhibit (Tunnicliffe and Reiss, 2007; Scheersoi and Tunnicliffe, 2009). Dioramas are unique as models in science in that they depict what is already recognised as plants or animals rather than rendering visible what cannot be seen such as

atomic structure and molecules or seek to physically embody abstract ideas or complex theories. The dioramas here did capture the visitor's attention to stop and look with meaning. Data from the dioramas (drawings and interviews) clearly show that pupils in this research acquired biological knowledge and include organism and artefacts from what interests them, example they included recognisable birds or butterflies mostly and physical structures like buckets, spades, the sun and clouds. A majority of pupils selected a diorama similar to a place they were familiarity with, example choosing the Sand Dune if they liked the beaches (Garibay and Gyllenhaal, 2015).

Visitors at dioramas have opportunities to construct knowledge about flora, fauna and the habitat they live in. The diorama drawing of every pupil was partly a representation of the diorama with external inclusion (sun and clouds) showing that children constructed meaning from the animals, plants and artefacts they observed in the setting and elsewhere (Bruner et al., 1956). It is implied that discovery learning occurred and students constructed their own knowledge without being aided by adults or museum panels.

As snapshots in time, dioramas provide children with the chance to stand, observe, identify, raise questions and seek answers. 'Stand and stare' opportunities are not often possible at places with live specimens. The school children in my research recognized, identified and worked out ecological relations between specimens as well as selecting the flora and fauna in the diorama. At dioramas, children develop the inquiry approach: they observe, ask questions, formulate hypothesis, which they try to validate by comparing scene in the diorama with their own experiences and previous knowledge (Tunnicliffe and Scheersoi, 2015). Scheersoi (2015) states that interest and learning can occur at dioramas if these evoke emotional responses. The audio recordings had evidence of emotional responses to for example the rats, bats and snails (gliding on glass cover). Visitors had opportunity for 'animal encounters' as provided by dioramas due to the possibility of close observation. Rare animals (the weasel), animals in motion (flying birds), interacting animals (birds on sand in Sand Dune) or artefacts (Maltese boat) in the diorama capture the children's attention. Narratives could be seen in some of the drawings clearly telling the story as depicted by the diorama, an ecological story in this case.

Smaller dioramas, like those found at the Natural History of Malta, offer greater potential for learning from a short museum encounter (Peart and Kool, 1988: 127). Dioramas provide children with opportunities for 1) observation, 2) classification and naming, 3) habitat and ecological appreciation and 4) cultural exposure. There are however two issues:

1. In dioramas organisms are static, so this might be problematic in the sense that children associate 'life' with motion, if it moves then it's alive. In fact most pupils drew birds in flight or other animals such as butterflies in motion.
2. It is not desirable for pupils to have a model of the environment as simply a background against which isolated organisms stand (Tunnicliffe and Reiss, 1999). Habitat dioramas do, to a certain extent, present animals and plants in this way even though attempts are made to present animals in motion, e.g. bird in flight or snails crawling on glass pains. Nonetheless they are still motionless.

Learning is embedded within social events and occurs as a person interacts with people, objects and events in the environment. Viewing a diorama is also a social experience and varies depending on the culture from which the participant hails and the context and culture in which they are viewed (Tunnicliffe and Scheersoi, 2015). Pupils observed the dioramas in groups of 4 and were allowed to speak and exchange ideas, as a social unit within the cultural setting of the natural history museum of Malta.

6.7 Sources of knowledge

What sources of knowledge influence children in the construction of their mental models? Children produced pictorial compositions based on their personal experiences. Before looking at the dioramas, children possess a mental model that is influenced by what they have encountered through experience and in the various media sources. The mental model could include other animals or species from various other countries, non-endemic. The diorama is a local setting of a typical habitat, with local species, small and inconspicuous at times and often disregarded or disrespected. There are trends, similarities in the types of animals selected.

Learning about the environment and science is equally effective outdoors as it is in the classroom. Children of different ages come to the classroom with their own ideas about and experiences with animals (Patrick and Tunnicliffe, 2011: 640; Tunnicliffe et al., 2008: 220). In this research, the order of importance of the knowledge source was: a garden or woods (close to their home town), countryside, television, films, internet, books, pets, farm, holiday and home. To Maltese children school and books are secondary to direct observation as reported by Bartoszeck et al. (2009) with Brazilian children and Tunnicliffe and Reiss (1999) in a study with English children, thought in the latter case home was the first choice. Huxham et al. (2006) also in the UK, cited television, films and book as the main sources, while in one of few studies done in Malta, Gatt et al. (2007) mentioned parents as the main source. Very few children in this research mentioned parents or family members.

Children in this study spent time in the countryside surrounding their home town or in the nearby Howard Gardens where they have opportunities to observe animals and plants. The media sources, TV program, internet sites accessed, type of film or books read might not have adequate scientific content on animals and plants. Children do spend appreciable time watching TV and browsing the internet, but they probably follow program or films on various subjects other than wildlife. So these results do not support what Huxham et al. (2006) stated that cultural sources of information about wildlife are more influential than direct observations. The reduced importance of school and books is not very comforting for science educators promoting leaning in schools (Tunnicliffe and Reiss, 1999: 146). It is also a reflection on the little time being spent in Maltese primary schools on science education in general (Martin et al., 2011). However, it is reassuring that out-of-school experiences are still an important means of learning.

6.8 Impact of the visit

The children on the museum visit in this research were novices with limited preparation, had never been to the museum and therefore required orientation. Falk et al. (1978) concluded that novel settings interfere with learning and educators need to consider novelty as an extremely important educational variable during field trips. The novel field-trip factor was not a barrier to learning, but rather an interaction between the child and her environment (Falk, Martin & Balling, 1978: 7; Stronck, 1983: 289). The children in this research were new to the museum environment and this did seem to affect the children's behaviour and level of interest in a positive way.

Nine-year-old children would be expected to behave differently in the unfamiliar environment of the natural history museum as opposed to the controlled and familiar environment of their classroom. In actuality, it was the behaviour of the class as a group that varied. The first group to arrive at the museum was class 5.2, a mixed group of nine to ten year olds. They were very active, rather unruly and quite difficult to control. Two of the children in this group did not hand in a diorama drawing, most probably because they left the area earlier than the rest of the group. Class 5.3 was the next group to arrive and were much better behaved and organised, with very few students roaming around freely. Class 5.1 was last in the museum and were the best behaved, disciplined, and well organised and generally better prepared for the visit. The group was more focused on task and worked very diligently throughout. It was well documented in literature that teachers play a vital role in school visits and well-prepared students reduce management time. While teacher involvement can vary greatly, most tend to be passive or simply involved in technical support (Davidson et al, 2009; Hooper-Greenhill, 2000; Kisiel, 2006; Parsons and Breise, 2000; Patrick et al., 2011; Price and Hein, 1991; Tal et al., 2005; Tal and Morag, 2007). The level of preparation and control exerted by the individual class teacher determined the type of behaviour shown by the class as whole and by the pupils individually. It was clear that the class teacher of group 5.1 had prepared his pupils very well for the visit and was actively involved in the museum activity. The other teachers were more concerned with managing their group and this could explain why class 5.2 was rather unruly.

Pupil behaviour could also be a result of teachers acting as guides at the NHM of Malta since there were no docents or museum educators as yet there. Students on unguided tours found the museum to be more exciting, less confusing, and more useful, and the majority (50%) of students preferred a docent as their teacher when visiting the museum (Stronck, 1983: 288). Students also wished that they could touch and feel more things, but unfortunately the NHM of Malta provides no opportunities for touching and feeling objects (Buttigieg, 2001: 55).

When learning outside the classroom was an integral part of the curriculum, this alleviated the demands on staff for planning of educational objectives and the practicalities of the visit (OFSTED, 2008: 22-24). The OFSTED (2008) report refers to the English situation, but its general conclusion may well apply to Malta where the educational system was quite similar to that in Britian. Notwithstanding that not all worked out as planned, the teachers commented that they had never been to a visit that was so well organized with well planned activities to aid the children's learning at the museum.

On arriving at the museum, practically all the children were fascinated by the bird displays in the open bird hall housing a vast array of resident and mostly migratory bird species. Children were struck by the variety, size and plumage of the birds on display. Some children noted that some bird specimens were missing legs, eyes and other structures. Children and teachers commented on the presence of dead preserved animals in the museum. Showing awareness about animal welfare and cruelty, they enquired whether the animals had been killed for the purpose of producing exhibit specimens. I responded by briefly explaining how animals were preserved using the technique of taxidermy and that none were purposely killed for displayed in museum. Two students were observed roaming about and did not hand in their work.

The children's visit to the NHM was part of their environmental education and also a means of enhancing their awareness of local animals and plants. Most effectively managed schools and colleges in England included learning outside the classroom as an integral part of a well-planned curriculum (OFSTED, 2008: 4). Learning in non-school settings on field trips and visits to museums was strongly connected to school curriculum and learning activities (Dierking, 1991). In-school and out-of-school learning experiences were at the ends of a continuum and this perspective moves away from the traditional dichotomy of formal versus informal learning and was more in-line with Falk's idea of choice opportunity, since the faculty to choose what to learn was not exclusive to non-school environments (cited in Tal and Morag, 2007: 3).

All learners involved in the survey found working away from the classroom 'exciting', 'practical', 'motivating', 'refreshing' and 'fun'. Following a class lesson, pupils became animated and involved once they had the opportunity to conduct their own research outside the classroom (OFSTED, 2008: pg.10). A study in the Malta sister island of Gozo reports the pupils' enthusiasm, involvement, quest for knowledge, desire to try things, enjoyment and excitement during a visit to a science center (Buttigieg, 2001: 55).

The next chapter 7 presents the main conclusions from the data analyzed and the discussion that ensues. The methodological, drawing and visit limitations are recognized and highlighted. The major contributions to the field of knowledge are clearly stated and recommendations for museum learning and further research given.

7 Conclusions

In this concluding chapter, I review the main limitations of the methodology of this research, limitations of the data collected and drawings, and limitations of class management and handling during the visit. Next I discuss the major conclusions that emerge from the data mainly; drawing as influenced by context and novelty effect of the museum; predilection by Maltese children for animals, particularly the cultural importance of birds; dioramas aid the recall of familiar environments and accommodate 'new' knowledge; progressing from imaginary drawing to observational drawing children show changes in perspective and relationships between organisms; children interpret the diorama through the lens of their current mental model; sources of knowledge about animals and plants; the potential for dioramas as models in science education. Here I state the main contribution to knowledge that I make through this research project; the mixed-methods approach and the new theoretical model for interpreting dioramas and other artefacts.

In the final section, I put forward a number of recommendations for the establishment of an educational program at the NHM, the setting up of a protocol for field visits in Malta; the use of dioramas in learning in biology and environmental science, and possibilities for further research.

7.1 Methodological Limitations

The research I present here is based on a relatively small-scale study conducted in one primary state school with fifty-seven participating pupils and it may not therefore be representative of other areas in Malta. Although one might not draw too many conclusions, results may be of wider relevance given that Malta is a small country with a relatively homogenous student population.

A shorter period (a week) between class, museum and post visit tasks instead of three and two weeks respectively would have helped to minimise any interferences, but for logistic reasons this was not possible. Ideally, the children were interviewed about their drawings at the museum, but this would have been too time consuming and neither was it possible to conduct the interviews within a day or two after the visit. Four pupils who participated in the class drawing task did not attend the museum visit, thus reducing the sample size further (originally one disabled male and another female student refused to participate in the research). It is unfortunate that there are still parents who feel that field trips are a waste of time and not an integral part of the curriculum.

Few problems were encountered during the first task carried out in the accustomed environment of the classroom, except that some looking over and copying was unavoidable with pupils working so close to each other. This is not necessarily a negative practice as children can pick up ideas from each other (Hopperstad, 2010). We should not assume that children's drawings are print-outs of mental images (Jolley, 2010) and that children never just copy (Kress, 1997). Granted that some children did copy from their peers' work, each drawing expresses a unique context for the visual forms and structures that are copied (Hopperstad, 2010: 447; Kress, 1997: 37). There is little evidence in my results that children actually copied and very few drawings by different pupils look similar.

Other limitations included:

- Time for interviews was limited (average 8 minutes each) and the last 3 or 4 interviews were conducted under pressure. Some pupils were quite reserved and provided limited responses to the questions asked.
- The museum posed limits of space, mainly the diorama area is too small to accommodate more than 5 to 7 pupils at once and there is not enough depth to permit the viewer to stand back and obtain a wider view of the diorama.
- Conversations in the diorama hall were recorded, but the cross talk made it very difficult to distinguish the individual pupil talking. Thus, a full transcript was not possible, but salient comments were noted.
- The main data source is drawing (supplemented by interviews and webs), while other methods such as questionnaires were not employed.

Visual methods are appropriate to use with children as they are widely regarded to be "child-centered", age-appropriate and non-verbal means of communication with the potential to allow children to express themselves (Brooks, 2005; Malchiodi, 1998; Mitchell, 2006). Even though the use of drawings poses limitations, it is still worth using drawings as a data source. Reasons are the relative ease of obtaining a rich mass of data and also as an alternative to verbal expression enabling children through drawing, to show things that they cannot put into words (Lewis & Green in Bowker, 2007: 79). However, there are limitations in drawings as a data.

7.2 Limitations of drawing as a data source

This study adds a qualitative dimension to assessing visitor impact, allowing for a better understanding of the benefits and limitations of museum visits. Means such as webs and drawing items allow for direct access to learning that occurs at a museum. The use of drawings is particularly indicated in the case of children in that it does not conform to the conventional prioritization of the linguistic within social research methods, but rather being a data collection method that is primarily visual (Jensen, 2011). However, drawings do have limitations as data collection means in that some pupil's drawing ability may constrain the level of detail they can add to their drawings particularly the more knowledgeable ones. The manual skill barrier poses a risk of concluding that there is no impact when there in fact is educational impact that the child is unable to express.

In all of the drawing tasks pupils said they had difficulty in drawing or they did not have enough time to finish or include other items. This is especially true for the Diorama Task, 53% of pupils had difficulty in drawing their preferred setting, while 20% of pupils drew features (mainly animals) and afterwards erased them. Children still believed that there were expectations on the quality of their drawing and that what they were drawing was not 'good enough'. It seemed evident that certain children drew few features because they lacked the confidence to produce a complete picture or they required more time to finish their work. An open-ended instruction (such as 'Now I want you to draw something') may encourage some children to draw directed by personal agendas and interests. However, others may feel insecure and draw what they believe the teacher would expect and approve (Anning and Ring, 2004).

For the task before the viewing of the dioramas, a few children drew what they had observed in the bird hall, rather than what I instructed them to draw, namely a 'a place with animals and plants in Malta'. In the museum context, working in a new and different environment to the classroom, the children enjoyed greater freedom to explore and express themselves and this could explain the behaviour of these few. Some children were concerned that their drawing wasn't of the 'desired' quality, notwithstanding that I assured them that every drawing was acceptable. They persisted in asking whether their drawing was 'good'. Drawing skill was not an issue, but rather the use of drawing to visualize their thoughts (Alerby, 2000: 210, Gardner 1980: 262). Students erased and redrew features of their drawing or even discarded the paper and started all over again, confirming what was reported by Hopperstand (2010) in a study carried out with 35 Norwegian 6 year olds. He observed children who made four versions of an object before they were pleased with the result. A child may refrain from drawing if it proves to be too daunting a task or the child is not satisfied with the quality of the drawing. Critical remarks may cause a child to give up the drawing and start all over again (Gardner 1980: 262; Hopperstad, 2010: 448).

During the diorama-drawing task, some children wanted to return to the diorama hall to have a second look at the particular one they chose to draw. A few even took notes of the setting they planned to draw as an aide memoire while drawing. Others lurked behind in the diorama area to have a longer look before leaving to go and draw. Such behaviour indicates that the children were preoccupied of forgetting details and that they wanted to produce the best possible representation of the chosen setting. There is a concern to meet the teacher's or in this case researcher's 'expectations'. Children are increasingly inclined to looking at things just the way they happen to be and are concerned to make the drawing look recognisable (Cox, 1992: 95; Gardner, 1980: 149).

One concern with drawing is that the narrow range of possible images that can be reflected in children's drawings may not be fully representative of their understanding of nature. This calls for the need to supplement with Webs and interviewing (Keliher, 1997: 241).

7.3 Limitations of the Visit

It was not possible to monitor all children that were in a novel, spacious and interesting environment. This possibly reflects a lack of field trip experience and preparation on the part of the teachers and also inadequate teacher training in informal learning. There were only two adults tending each class and no museum staff at all. A museum is after all a place for free learning and so children would be expected to wander off attracted by whatever was of interest to them. Part of the pupils' time was allowed for "looking around" perhaps at the expense of the knowledge they were on the trip to gain (Benz, 1962: 49). However, the role of the 'more knowledgeable' other in scaffolding aids learning and thus the involvement of museum educators or teachers in assisted learning would enhance the potential of a museum experience (Jenson, 2011).

The class teacher can organize activities as specific preparation that reduces the novelty factor and aids meaningful learning during the field trip. 'Novelty-reducing preparation' increases on-task exploratory behaviour and greater cognitive learning (Kubota & Olstad, 1991; Orion and Hofstein; 1994). The three factors (a) level and type of knowledge and skills, (b) acquaintance with the field trip area, and (c) psychological preparation all help to reduce the "novelty space" to a minimum and facilitate meaningful learning during a field trip (Orion and Hofstein, 1994: 1116-7). Drawing before the visit not only probes knowledge, but also helps to improve drawing skill and affords a degree of psychological preparation.

Class preparation and teacher involvement is crucial in a museum visit and this was evident from the varying behaviour of the different classes participating in the research. Evidently, the teacher of one of the classes (class 5.1) had pupils very well prepared for the visit and was actively involved in the museum activity.

7.4 Main Conclusions

This thesis is not only one of few out of school studies in Malta and a first on habitat dioramas and their potential in biological education, but also a first in the field on the potential of habitat dioramas as biological models for visualization and interpretation of animals and plants. Other studies (Patrick et al. 2013) have shown which animals young people (6, 10 & 15 years) notice in the environment of six different countries, but no study has shown this explicitly from natural history dioramas before my work here. General trends in the drawings produced emerged; common themes through the drawings produced show that pupils use their knowledge to make sense of the diorama they viewed and selected to draw, example those that drew a garden or the countryside (class & pre-diorama) selected the 'field' or the 'house yard' that may elicit memories of things one sees in gardens and the countryside or if seaside was drawn they selected the sand dune diorama. Not all pupils are able to make such clear connections as evidenced by drawings showing a conflation of dioramas. The strong cultural presence of the superordinate 'bird' among Maltese children is quite clear. They also seem to prefer more endemic species than exotic foreign species, which is does not concur with what was found in other countries. As far as plants are concerned, seeded, large woody trees such as apples, oranges and cherries seem to prevail even though in Malta only orange trees can be seen around. There is a clear preference for animals over plants. Maltese children seem to confirm the general "plant blindness" characteristic reported in literature (Wandersee and Schussler, 2001).

7.4.1 Cultural tradition and birds

Malta has its own different culture with a long and deep-rooted tradition of bird trapping and hunting. The importance of birds is quite clearly evidenced in the data; birds are consistently the most frequently drawn animal in the three drawing tasks, which varies from what was reported in other countries in that mammals are the preferred class of animals. Most pupils (82%) included a similar number of birds in all three drawings, presented in similar iconic mode and show in flight (23%). The choice of or preference for dioramas (Sand Dune and Bastion) containing flying birds is influenced by held knowledge (shown in previous drawings) and the culture. Drawing is socially shaped and culturally given resource for meaning making, but with characteristics that vary in different cultures and Malta shows its own cultural features too. In Malta hunting and trapping have strong cultural roots and this is directly shown in some of the drawings, but this strong Maltese cultural aspect evidently influences frequency and types of birds shown.

7.4.2 Context and Novelty

The context of drawing (where it is done) that is, if done in the formal environment of the class or the informal setting of the museum, may appreciably influence the outcome. The novelty factor of the museum also affects the drawings produced, by some children more than others. There are pupils whose drawing loses much of its richness, colour and perspective shown in class indicating that the museum context caused a regression in performance.

For others there did not seem to be any particular effect since their drawings remained practically unchanged. In the museum pupils preferred to draw much more birds than mammals and arthropods compared to what they did the class. The dioramas were a new experience for all the pupils who had never been to the museum before. For almost half the pupils (47%), the dioramas had a positive impact enabling them to present animals and plants with better perspective, and showing ecological relations. However, there are pupils who either were not affected or experienced a regressive effect. This might be a consequence of the novel environment and the pupils being novices at this learning experience (none had ever visited or participated in any learning activity of this sort). Could have some form of 'assisted learning' or scaffolding been of any benefit in this case?

7.4.3 Visualizing the habitat dioramas

The way children see and interpret the dioramas is the central premise of this research. To a certain extent, most children seem to interpret the diorama through the lens of their previously held mental model. So what they pick out or choose to represent depends on what model they already hold. Dioramas that help recall familiar environments or elicit previous knowledge and interest are more likely to capture attention and afford a longer viewing time, thus accommodating new knowledge and moulding the child's mental model. Habitat dioramas promote a sense of perspective as seen in the greater sophistication observed in almost half (47%) of the diorama drawings in terms of relative sizes of organisms and their position in relation to each other. However, perspective is reflected in some drawings, but not in others. This is an indication of successful 'self-guided' learning for some pupils, but less so for the others. The latter category of pupils might have actually assimilated 'new' knowledge, but were incapable of expressing it or they required a 'more knowledgeable other' to scaffold their learning. It should be recalled here that the Natural History Museum in Malta does not provide museum educators or docents. More knowledgeable peers could have only assisted pupils in this research.

There is a progression from drawing from imagination in class and at the museum before viewing the diorama, to increasingly drawing from observation, but still showing signs of imagination in the diorama drawings. There is a greater sense of intellectual realism rather than visual realism as evidenced in the 9 year olds participants in this research.

7.4.4 Sources of knowledge acquisition

Children come to the museum with their individually formed mental model. The latter is influenced by what they have encountered from experience and in the various media sources. The knowledge sources given by children in this research is in order as follows: a garden or woods (close to their home town), countryside, television, films, internet, books, pets, farm, holiday and home. In just one other study, parents were mentioned as the main source (Gatt et al., 2007).

7.4.5 Habitat diorama as a model in science education?

Literature documents the potential of habitat dioramas as valuable resources for learning in biology, but they have not been considered as science models for biological learning. Dioramas are elaborate depictions of constructed habitats that may serve as a model for real habitats and enable visitors to discover and learn about flora and fauna. The visitor has the opportunity to get very close to the organism, stand for as long as he or she wants and observe the animal in a habitat rather than isolated with lack of context. This may be done through the interpretative model I propose in the previous chapter in section 6.5.

7.5 Contribution to Knowledge

This thesis treats a relatively under-explored area in this field of study within the socio-constructivist paradigm. This is the manner by which natural history (habitat) dioramas in a Maltese context can serve as a pedagogical tool to help children better understand local flora and fauna. There are number of contributions to knowledge which I believe this study provides.

First, this is a first doctoral study on habitat dioramas in the field and on their potential in biological education and as models for visualization and interpretation of animals and plants. Secondly, methodologically it offers a novel range of data collection tools in a mixed-method approach and also a new analytical method using Atlas.ti to generate semi-quantitative data. Thirdly, it offers a model to theorise how natural history dioramas can be used to obtain an understanding of flora and fauna and how the model could be employed beyond the specifics of this study.

7.5.1 Mixed-Methods Approach

The empirical work was carried out using different data tools, namely: drawings, webs (mind maps), one-to-one interviews, observations and audio recordings. The main data are the drawings, which are a rich source that probe the child's thinking about artefacts and phenomena. Empirical studies of children's drawing date back to the latter part of the nineteenth century, however very few empirical studies have made use and evaluated the potential of drawings as data collection tools. Psychological research has a century-old tradition of using children's drawings, but other than art education, drawings rarely feature in educational research.

Most of the methods for gathering information on pupils' understanding of scientific phenomena rely mainly on speech and writing, but children are quite capable of communicating through drawing and this should be exploited as far as possible (Mavers, 2003). Drawing is considered to be an age-appropriate and by which one can obtaining a rich mass of data of the child's mental model with relative ease. A drawing's international suitability transcends the huge diversity of languages (Reiss et al, 2002: 59). In this research, I asked children to draw three drawings, to enable me obtain insights into their mental models. The drawings probe the mental models children have of places with local and animals and plants. I discovered how children visualize flora and fauna in the habitat dioramas they observed. The drawings graphically show which animals and plants preferentially grab their attention and how they were represented. Anatomical features, orientation and ecological relationships become evident. Some children are capable of producing very elaborate pictures with high graphical quality. Others just present one or two isolated animals with in no background or link. It is crucial to ask the pupil about his or her drawing to gain the child's interpretation of the drawing to avoid misinterpretation. Interviewing the children is important since it is an opportunity to explore further thinking about the drawing, but also other aspects such as what influences and knowledge sources the child possesses. Drawings are difficult to interpret without the child's verbal recall, which could lead to incorrect inferences about the drawer's intended meaning. It is a recognized fact that children provide more information than they actually draw (Jolley, 2010: 238). I also asked for a web (mind map), to obtain further evidence on knowledge, which dose not feature in the drawing, meaning that pupils frequently know more than they actually draw. A drawing might not show all that a pupil knows, but it has a narrative of it's own. The set of three drawings enabled me to follow the progression from class to museum to diorama and elicit any changes of biological significance. This method may be applied to other out-of-class settings, such parks, fields, gardens, zoos and nature reserves. In fact drawings have already been used in zoo research (Jensen, 2011; Tunnicliffe, 1999).

Drawing does have its shortcomings and is by no means a problem free activity. I have above underlined how drawing does not uncover all that a child knows about animals and plants. Drawings are not precise measurements of something as intangible as the implicit or explicit nature of the internal representation (Jolley, 2010: 178). It is crucial not to overlook the question of discrepancy between competence (cognitive) and performance (drawing). In this research I learnt that time constraints, pupils' confidence in drawing and the expectations they believe their teacher or researcher might have, all pose limits on drawing performance. So, although drawings are a unique and rich data source, it is wise to supplement this data with other tools such as interviews, questionnaires and simple written narratives. I learnt that analysing drawings is more arduous and terribly time consuming than I had expected, particularly if there are quite a few drawings to look at. I also directly observed and audio recorded the children as they interacted with the museum settings. This provides addition behavioural data and conversations that occur between the pupils. The affective as well as biological comments are made while observing the museum settings. Video data would have been useful, but the area was too small to allow this and I did not have permission and ethical approval to video the children.

I used Atlas.ti (software package) to generate semi-quantitative data as well as qualitative data. The package is designed to handle various media sources and very use for analysing drawings. To my knowledge this is the first empirical study in science education that uses the package to analyse drawings. I would recommend its use for analysing visual data, but being well acquainted with the package would appreciably reduce the hardship of the analysis.

7.5.2 The Theoretical Model

In chapter 6, section 6.5 I present a new Interpretative Model for the understanding of artefacts and the particular focus (subject matter) they offer. I based the model on *Activity System* (section 3.4.1), which I thought offers an adequate structure for it, with additional features from data. Focus, Artefact, Group and Subject are adopted from Activity theory, while Culture, Previous Knowledge, Mental Model and Expressed Model stem from the data. The model may be used to interpret museum objects (habitat dioramas) or applied to other artefacts such as pictures, 3D models and other media forms.

The strengths of the model lie in the manner it links together the elements involved in the interpretation of an artefact (mediating tool) to understand the message it conveys, for example Natural History Dioramas present flora and fauna in their habitat showing possible ecological relationships. It elucidates how a learner may understand a topic as mediated by an artefact to construct an intangible mental model to create a tangible expressed model (a drawing). The interaction with peers, the cultural baggage possessed and knowledge held may influence the mental model constructed. Potentially, this may apply to various topics as presented or modelled by 2D, 3D or virtual mediating tools. This may be done in different learning situations in science and other areas in formal, non-formal and informal settings.

The model's limitations lie in:
a) Firstly it assumes that the learner would use the artefact affectively. However he might concentrate on specific items in the setting ignoring the bigger picture. An *artefact* may not be effective in understanding the *focus*. Some features may actually distract the learner or capture his attention for aesthetic reasons only.
b) The degree or quality of interaction between the learner and his peers may be uncertain. The role of a more knowledgeable peer may be difficult to determine.
c) The *mental model* is very personal and varies from person to person. To what extent is the mental image modified and developed by the learning experience.
d) The *expressed model* is rarely a 'true' replica of the *mental model*. A drawing

is normally a selection of what really interests the person from what he observes and earlier learning.

e) *Culture* and *previous knowledge* are both long-term factors, which influence the way persons learn, acquire new knowledge and build *mental models*. However, it is difficult to measure the effect these have on the learner and his *mental model*.

7.6 Recommendations

There are some recommendations that I believe are pertinent at this point. These mainly address the following areas: the museum and services offered, a protocol for field visits, the Maltese primary science curriculum, teacher education and preparation and further research avenues.

7.6.1 Natural History Museum

The NHM in Malta is one of the remaining museums that still houses dioramas and their potential should be realised to the full. The building is not suitable for its purpose, with issues of accessibility (no lift) and space (small rooms). Particularly the diorama area, which is very narrow, closed, ended and with poor illumination and which does not enhance the value of these unique settings. The current premises does not have any other available spaces to relocate the diorama, therefore a new building for the museum and the dioramas is required. There are no panels or aids to interact with the dioramas and very little space to allow for comfortable viewing and circulation by visitors. However the most pressing need is the services of educators and programs for learning, particularly for school parties and family visitors. Scaffolding and didactic communication from the museum staff and those accompanying the children may enhance learning about local flora and fauna. The children in the museum in this research were mainly on a 'self-guided' visit operating in a zone of 'autonomous learning' with practically no potential 'assisted' learning since there are no museum educators or docents or 'more knowledgeable others' (Jensen, 2011).

7.6.2 The curriculum and field trips

The current primary science curriculum makes no specific reference to learning about animals and plants, while there is no explicit reference to science learning outside the classroom. This is currently under review, so it would be appropriate to make clear reference to the need for out-of-class learning and the NHM as one of the venues for learning in Biology. Allen (1975) recommended that each student should be allowed to interact with and experience novel settings in a personally satisfying and, perhaps, unique way (Stronck, 1983: 289). When learning outside the classroom is an integral part of the curriculum, this alleviates the demands on staff for planning of educational objectives and the practicalities of the visit.

In the UK, OFSTED (2001) established a set of national standards for out of school experiences and apart from achieving the National Standards, the providers are also expected to follow a set of regulations given in the same document. In Malta there is no such document on standards for field trips and so schools have no proper guidance or establish protocol to follow. Thus, it is highly recommended to compile a set of standards and procedures for field trips that schools in Malta would be expected to follow. In its report *Learning Outside the Classroom*, OFSTED (2008) give recommendations on how Central Education authorities and Local authorities could better support and encourage schools in enriching the quality of out-of-class learning, and on how schools and colleges could provide meaningful out-of-class experiences for all their students. There is no analogue to OFSTED in Malta, but there is a standards in education authority (DQSE) which may follow suite on OFSTED's work, particularly since the Maltese education system is similar to that in Britain.

> *'In the best primary visits, staff, parents and other volunteers supervising the pupils were given clear guidance about the expected learning and how to promote it, for example by asking key questions. However, this was not always done well, with the result that the focus on learning in the minds of adults and pupils was diluted'* (OFSTED, 2008, pg.15).

Patrick et al., (2011) report that pre-service teachers thought planning was important, children didn't learn very much about the exhibits or animals, field trips were a waste of time and that it was hard to have a successful field trip. They concluded that when teachers prepared their students properly before a trip, less time would be spent on management and more would be spent on learning. Thus, teacher education programs in Malta need to include field trip design and informal educational experiences that could lead to more educationally focused field trips.

Pre-service teachers recognize the importance of field trip preparation, but do not understand what is involved in designing quality field trip experiences. Patrick et al. (2011) suggest that:

> *'Preservice teachers should be introduced to the idea that preparation, follow-up activities, and reinforcement discussion are a vital part of field trip planning. Moreover, the visit should be planned as a three-part unit: before, during, and after the field trip'* (pg. 22).

In a study in Malta, Buttigieg (2001) reports that not all teachers felt confident, nor were they confident in such an environment and in the scientific investigations carried out.

7.6.3 Drawing for learning in the curriculum

There is no mention whatsoever to the value of multimodal means for learning in the curriculum, particularly the use of drawings as a learning tool. Mavers (2003) asks; Should we value the semiotics of children's drawing and writing when this is not specified in curricula or subject assessment? Valid reasons to do so could be:

i. accepting the diversity of resources children possess, multiculturalism
ii. rendering respect to presentations across social environments
iii. rendering respect to presentations across social environments

Concrete concepts allow individuals to build both verbal and visual representations, and coding information in these two formats increases the likelihood of successful encoding into memory and successful retrieval at a later time. Thus, information should be presented by children in multiple modalities to ensure that individuals will remember the contents of their learning experiences (Gilbert, 2008).

7.6.4 Further Research in the field

I have already stated that this research is a first for Malta and one of very few in the academic field, perhaps the first on habitat dioramas and their role in education. However, this is a limited study carried out with one state school in a small country like Malta with its culture and unique educational setting. There is certainly more scope for a larger study with a wider scope involving more schools, state and non-state and a larger pupil sample from different areas from the island which would allow for a comparative assessment in the Maltese context. Further research could explore the use of other data collection methods such as written narratives and questionnaires, involving pupils of different ages and assessing retention after some weeks. Another possibility could be a longitudinal study over 3 or 4 years and the assessment of a pilot educational program for the NHM in Malta.

References

Adams, M., Falk, J. H., & Dierking, L. D. (2003). Things Change: Museums, Learning and Research. In M. Xanthoudaki, L. Tickle, & V. Sekules (Eds.), *Researching Visual Arts Education in Museums and Galleries*. Dordrecht: Kluwer Academic Publishers.

Alerby, E. (2000). A Way of Visualising Children's and Young People's Thoughts about the Environment: a study of drawings. *Environmental Education Research, 6*(3), 206-222.

Anderson, D. (2012). A Reflective Hermeneutic Approach To Research Methods Investigating Visitor Learning. In D. Ash, J. Rahm, & L. M. Melber (Eds.), *Putting Theory into Practice*. Rotterdam: Sense Publishers.

Anning, A. (1997). Drawing Out Ideas: Graphicacy and Young Children. *International Journal of Technology and Design Education, 7*(3), 219-239.

Anning, A., & Ring, K. (2004). *Making Sense of Children's Drawings*. Berkshire: Open University Press.

Arnheim, R. (1969). *Visual Thinking*. London: Faber & Faber.

Arnheim, R. (1974). *Art and Visual Perception: a psychology of the creative eye*. Berkeley: University of California.

Ash, D. (2004). How families use questions at dioramas: ideas for exhibit design. *Curator, 47*(1), 84-100.

Ash, D., & Rahm, J. (2012). Introduction: Tools for Reseach in Informal Settings. In D. Ash, J. Rahm, & L. M. Melber (Eds.), *Putting Theory into Practice*. Rotterdam: Sense Publishers.

Atkinson, D. (2002). *Art in Education: Identity and Practice*. London: Kluwer Academic Publishers.

Bang, M., Medin, D., & Atran, S. (2007). Cultural Mosaics and Mental Models of Nature. *PNAS, 104*(35), 13868-13874.

Barry Lewis, R. (2004). NVivo 2.0 and ATLAS.ti 5.0: A Comparative Review of Two Popular Qualitative Data-Analysis Programs. *Field Methods, 16*(4), 439-469.

Bartoszeck, A. B. (2009). *Animals in children's Lives-Brazil.* Paper presented at the European Science Education Research Association, Instanbul.

Bartoszeck, A. B., Tunnicliffe, S. D., & Rocha da Silva, B. (2009). *Investigating Brazilian children's concept of insect.* Paper presented at the European Science Education Research Association, Instanbul.

Bell, B. F. (1981). When is an animal, not an animal? *Journal of Biological Education, 15*(3), 214-218.

Bell, B. F. (1993). A constructivist view of learning in *Chilren's Science, Constructivism and Learning in Science* (pp. 23-29). Waikato: Deakin University.

Benz, G. (1962). An experimental evaluation of field trips for achieving informational gains in a unit on earth science in four ninth grade classes. *Science Education, 46*(1), 43-49.

Bitgood, S. (1989). School Field Trips: An Overview. *Visitor Behaviour., 5*(2).

Bitgood, S., Sorrell, B., & Thompson, D. (1994). The impact of informal education on visitors to museums. In V. Crane, H. Nicholson, M. Chen, & S. Bitgood (Eds.), *Informal Science Learning: what the research says about television, science museums and community-based projects*. Dedham MA: Research Communications Ltd.

Black, G. (2005). *The Engaging Museum*. London: Routledge.

Borg, J. J. (2009). Dioramas: an untapped educational resource. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 5-6): ICOM Natural History Committee.

Borg, J. J. (2010). *Interview with the Curator of NHM in Malta*. Interviewer: E. Mifsud. Mdina.

Borg, M. G., & Falzon, J. M. (1990). Coping action used by Maltese Primary School Teachers. *Educational Research, 32*(1), 50-58.

Bowker, R. (2004). Children’s perceptions of plants following their visit to the Eden Project. *Research in Science & Technological Education, 22*(2), 227-243.

Bowker, R. (2007). Children’s perceptions and learning about tropical rainforests: an analysis of their drawings. *Environmental Education Research, 13*(1), 75-96.

Bowker, R., & Jasper, A. (2007). ‘Don’t forget your leech socks’! Children’s learning during an Eden Education Officer’s workshop. *Research in Science & Technological Education, 25*(1), 135-150.

Bradley, S. (2014). Design Principles: Visual Perception and the Principles of Gestalt. from www.smashingmagazine.com

Braund, M. (1991). Children's ideas in classifying animals. *Journal of Biological Education, 25*(2), 103-110.

Braund, M. (1998). Trends in children's concepts of vertebrate and invertebrate. *Journal of Biological Education, 32*, 112-118.

Braund, M. (2004). Learning science at museums and hands-on centres. In M. Braund & M. Reiss (Eds.), *Learning Science Outside the Classroom* (pp. 113-128). London: RoutledgeFalmer.

Braund, M., & Reiss, M. (2004). The nature of learning science outside the classroom. In M. Braund & M. Reiss (Eds.), *Learning Science Outside the Classroom* (pp. 1-12). London: RoutledgeFalmer.

Braund, M., & Reiss, M. (2006). Towards a more authentic science curriculum: the contribution of out-of-school learning. *International Journal of Science Education, 28*(12), 1373-1388.

Brooks, M. (2005). Drawing as a unique mental development tool for young children: interpersonal and intrapersonal dialogues. *Contemporary Issues in Early Childhood, 6*(1), 80-91.

Brooks, M. (2009). Drawing, Visualisation and Young Children's Exploration of "Big Ideas". *International Journal of Science Education, 31*(3), 319-341.

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, Mass: Harvard University Press.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A Study of Thinking*. London: John Wiley & Sons, Inc.

Buckley, B. C., & Boulter, C. J. (2000). Investigating the Role of Representations and Expressed Models in Building Mental Models. In J. K. Gilbert & C. J. Boulter (Eds.), *Developing Mdels in Science Education*. London: Kluwer Academic Publishers.

Burton, J. (1980). Developing Minds: the first visual symbols. *School Arts, 80*(2), 60-65.

Buttigieg, M. (2001). *An evaluation of a on-day activity at Dar il-Lunzjata Science Center. Unpublished disseration.* (B.Ed(Hons)), University of Malta, Msida.

Carey, S. (1985). *Conceptual Change in Childhood*. London: The MIT Press.

Carrier Martin, S. (2003). The Influence of Outdoor Schoolyard Experiences on Students' Environmental Knowledge, Attitudes, Behaviors and Comfort Levels. *Journal of Elementary Science Education, 15*(2), 51-63.

Carville, A. (2010). Brave New World. *Sunday Circle, No.183,* 45-46.

Cerini, B., Murray, I., & Reiss, M. J. (2003). Review of the Science Curriculum: Major Findings. London: Plant Science, Science Museum & IOE.

Chawla, L. (1998). Significant Life Experiences Revisited: a review of research on sources of environmental sensitivity. *Environmental Education Research, 4*(4), 369-382.

Cheng, J., & Monroe, M. (2012). Connection to Nature: Children’s Affective AttitudeToward Nature. *Environment and Behavior, 44*(1).

Chetcuti, D. (2009). *Primary Science: The views of Peripatetic Science Teachers and Key Administrators*: Mimeo.

Clodd, E. (2013). *Thomas Henry Huxley*. New York: HardPress Publishing.

Coates, E., & Coates, A. (2006). Young children talking and drawing. *International Journal of Early Years Education, 14*(3), 221-241.

Coe, J. C. (1986). *Towards A Co-evolution of Zoos, Aquariums and Natural History Museums*. Paper presented at the Annual Conference of the American Association of Zoological Parks and Aquariums, Wheeling.

Collins, G. (2003, 3rd February). Rescuing the Diorama from the fate of the Dodo; in new appreciation of old techniques, museum remakes the sea on dry land. *New York Times*.

Cotumaccio, A. (2015). The Evolution of the Narrative at Natural History Dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 187-194). London: Springer.

Cox, M. V. (1992). *Children's Drawings*. London: Penguin Books.

Cox, M. V. (2005). *The pictorial world of the child*. Cambridge: Cambridge University Press.

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of Guided School Tours, Student Learning, and Science Reform: Recommendations at a Museum of Natural History. *Journal of Research in Science Teaching., 40*(2), 200-218.

Cramer, J. R. (2008). Reviving the Connection between Children and Nature. *Native Plants, 9*(3).

Crane, V. (1994). Understanding the dynamics of informal learning. In V. Crane, H. Nicholson, M. Chen, & S. Bitgood (Eds.), *Informal Science Learning: what the research says about television, science museums and community-based projects*. Dedham, MA: Research Communications Ltd.

Davidson, S. K., Passmore, C., & Anderson, D. (2009). Learning on Zoo Field Trips: The Interaction of the Agendas and Practices of Students, Teachers, and Zoo Educators. *Science Education, 94*, 122-141.

Davis, J., & Gardner, H. (1992). The Cognitive revolution: consequences for the understanding and education of the child as artist. In B. Reiner & R. A. Smith

(Eds.), *The Arts, Education and Aesthetic Knowing: ninety-first Yearbook of the National Society for the study of Education* (Vol. Part II, pp. 92-123). Chicago: University of Chicago Press.

Debono, J. (2005, 6th November). Science without leadership as Malta lags behind Europe. *MaltaToday*.

Dierking, L. (1991). Learning theories and learning style: an overview. *Journal of Museum Education, 16*(4-6).

Dockett, S., Main, S., & Kelly, L. (2011). Consulting Young Children: Experiences from a Museum. *Visitor Studies, 14*(1), 13-33.

DQSE. (2005). Primary Science: Rationale. Floriana: Education Division.

Driver, R. (1983). *The Pupil as Scientist?* Milton Keynes: Open University Press.

Duncan, P. (1993). Ten Types of Narrative Drawing Among Children's Spontaneous Picture-Making. *Visual Arts Research, 19*(1), 20-29.

Dunmall, K. (2015). Storytelling and Performance in Diorama Galleries. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 243-250). London: Springer.

Eberbach, C., & Crowley, K. (2005). From Living to Virtual: Learning from Museum Object. *Curator, 48*(3), 317-338.

Education, M. o. (1999). *Creating the Future Together: National Minimum Curriculum.* Floriana; Malta: Klabb Kotba Maltin.

Edwards, B. (1979). *Drawing on the right side of the brain.* Los Angeles: J.P. Tarcher INC.

Engeström, Y., Miettinen, R., & Punamäki, R. L. (1999). *Perspectives of Activity Theory*: Cambridge University Press.

Eshach, H. (2007). Bridging In-school and Out-of-school Learning: Formal, Non-Formal, and Informal Education. *Journal of Science Education and Technology, 16*(2), 171-190.

Falk, J. H. (2008). Advancing the NSES vision through informal education. In R. E. Yager & J. H. Falk (Eds.), *Exemplary science in informal education settings: standards-based success stories*. Virginia: NSTA Press.

Falk, J. H., & Balling, J. D. (1980). The school field trip: Where you go makes a difference. *Science & Children, 17*(6), 6-8.

Falk, J. H., & Dierking, L. D. (2000). *Learning from Museums: Visitor Experiences and the Making of Meaning*. New York: AltaMira Press.

Falk, J. H., Martin, W. W., & Balling, J. D. (1978). The Novel Field-Trip Phenomenon: Adjustment To Novel Settings Interferes with Task Learning. *Journal of Research in Science Teaching., 15*(2), 127-134.

Falk, J. H., Storksdieck, M., & Dierking, L. (2007). Investigating public science interest and understanding: evidence for the importance of free-choice learning. *Public Understanding of Science, 16*(4), 455-469.

Fosnot, C. T. (1989). *Enquiring teachers, enquiring learners: A constructivist approach for teaching*. New York: Teachers College Press.

Freeman, N. H. (1997). Identifying Resources from which Children Advance into Pictorial Innovation. *Journal of Aesthetic Education, 31*(4), 23-33.

Friese, S. (2012). *Qualitative Data Analysis with Atlas.ti*. London: Sage.

Friese, S. (2012). ATLAS.ti 7: User Guide and Reference (pp. 433). Berlin: ATLAS.ti Scientific Software Development GmbH.

Gallup. (2008). Flash Eurobarometer 239: Young people and science (pp. 206): European Commission.

Gardner, H. (1978). *Developmental Psychology: an introduction*. Oxford: Little Brown & Co.

Gardner, H. (1980). *Artful Scribbles: the significance of children's drawings*. New York: Basic Books Inc. Publishing.

Garibay, C., & Gyllenhaal, E. (2015). Habitat Diorama and Sense of place: Factors Linked to Visitors' Feelings About the Natural Places Portrayed in

Dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 209-226). London: Springer.

Gatt, S. (2005). *Constructivism 25 Years on: Its Contribution, Missed Opportunities?* Paper presented at the Hands-on Science: Science in a changing Education, University of Crete, Rethymno.

Gatt, S., Tunnicliffe, S. D., Borg, K., & Lautier, K. (2007). Young Maltese children's ideas about plants. *Journal of Biological Education, 41*(3), 117-121.

Gatt, S., & Vella, Y. (2003). *Constructivist Teaching in Primary School.* Valletta: Agenda.

Gilbert, J. K. (2005). Visualization: A metacognitive skill in science and science education. In J. K. Gilbert (Ed.), *Visualization in Science Education* (Vol. 1). Dordrecht: Springer.

Gilbert, J. K. (2007). Visualization: A Metacognitive Skill In Science and Science Education. In J. K. Gilbert (Ed.), *Visualization in Science Education*. London: Springer.

Gilbert, J. K. (2008). Visualization: An Emergent Field of Practice and Enquiry in Science Education. In J. K. Gilbert, M. Reiner, & M. Nakhleh (Eds.), *Visualization: Theory and Practice in Science Education* (Vol. 3). Dordrecht: Springer.

Golomb, C. (2004). *The Child's Creation of a Pictorial World* (2nd ed.). New Jersey: Lawrence Erlbaum Associates, LEA.

Gomes, M. (2013). It's Not Just Child's Play: Nature's Powerful Effect on Children's Well-Being. *Tikkun Magazine, 28,* 7-12.

Goodnow, J. (1977). *Children's drawing*. London: Fontana Open Books.

Gordon, I. E. (2004). *Theories of Visual Perception* (3rd ed.). New York: Psychology Press-Taylor&Francis Group.

Green, M. (1986). Stephen Jay Gould; driven by a hunger to learn and to write what he knows, an outspoken scientist fight back from life-threatening illness. *People, 25,* 109-114.

Gunstone, R., & White, R. (1992). *Probing Understanding*. London: The Falmer Press.

Hammond, K. R. (2001). Expansion of Egon Brunswik's Psychology, 1955-1995. In K. R. Hammond & R. S. Stewart (Eds.), *The Essential Brunswik: beginnings, explications, applications*. London: Oxford University Press.

Haney, W., Russel, M., & Bebell, D. (2004). Drawing on Education: Using Drawings to Document Schooling and Support Change. *Harvard Educational Review, 74*(3), 241-271.

Hein, G. E. (1998). *Learning in the museum*. London: Routledge.

Hein, G. E. (1999). The Constructivist Museum. In E. Hooper-Greenhill (Ed.), *The Educational Role of the Museum* (pp. 73-79). London & New York: Routledge.

Hein, H. S. (2000). *The Museum in Transition: A philosophical Perspective*. Washington: Smithsonian Books.

Holliday, E. L., Harrison, L. J., & McLeod, S. (2009). Listening to children with communication impairment talking through their drawings. *Journal of Early Childhood Research, 7*(3), 244-263.

Hooper-Greenhill, E. (1994). *Museums and Their Visitors*. London: Routledge.

Hooper-Greenhill, E. (1999). Education, communication and interpretation: towards a critical pedagogy in museums. In E. Hooper-Greenhill (Ed.), *The Educational Role of the Museum* (2nd ed.). London & New York: Routledge.

Hooper-Greenhill, E. (1999). Museums learners as active postmodernists: contextualizing constructivism. In E. Hooper-Greenhill (Ed.), *The Educational Role of the Museum* (2nd ed., pp. 67-72). London & New York: Routledge.

Hooper-Greenhill, E. (1999). Learning from learning theory in museums. In E. Hooper-Greenhill (Ed.), *The Educational Role of the Museum* (2nd ed., pp. 137-145). London & New York: Routledge.

Hooper-Greenhill, E. (2000). *Museums and the Interpretation of Visual Culture*. London: Routledge.

Hooper-Greenhill, E., Dodd, J., Gibson, L., Phillips, M., Jones, C., & Sullivan, E. (2006). What did you learn at the museum today? Second Study. London: MLA Council.

Hopperstad, M. H. (2010). Studying meaning in children's drawings. *Journal of Early Childhood Literacy, 10*(4), 430-452.

Hordyk, R. S., Dulude, M., & Shem, M. (2014). When nature nurtures children: nature as a containing and holding space. *Children's Geographies*.

Hurwitz, A., & Day, M. (1991). *Children and their art: Methods for the elementary school* (5th ed.). New York: Harcourt Brace Jovanovich.

Huxham, M., Welsh, A., Berry, A., & Templeton, S. (2006). Factors influencing primary school children's knowledge of wildlife. *Journal of Biological Education, 41*(1), 9-12.

Ilyenkov, E. V. (1997). The question of the identity of thought and being in pre-marxist philosophy. *Russian Studies in Philosophy, 36*(1), 5-33.

Insley, J. (2007). Setting the Scene. *Museums Journal, 2*(107), 33-35.

Insley, J. (2008). Little Landscapes: dioramas in museum displays. *Endeavour, 32*(1), 27-31.

Jaworski, B. (1996). Constructivism and Teaching: The socio-cultural context. from www.grout.demon.co.uk

Jensen, E. (2011). Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme (pp. 4-102). London: University of Warwick and Zoological Society of London.

Johnson, S. (2004). Learning science in a botamic garden. In M. Braund & M. Reiss (Eds.), *Learning Science Outside the Classroom* (pp. 75-93). London: Routledge Falmer.

Jolley, R. P. (2010). *Children and Pictures: drawing and understanding*. Oxford: Wiley-Blackwell.

Kaku, M. (2009). *Physics of The Impossible*. London: Penguin Books Ltd.

Keliher, V. (1997). Children's perceptions of nature. *International Research in Geographical and Environmental, 6*(3), 240-243.

Kellert, S. R. (1996). Experiencing Nature: Affective, Cognitive, and Evaluative Development in Children. In P. H. Kahn & S. R. Kellert (Eds.), *Children and Nature: psychology, sociocultural and Evolutionary Investigations*. Hong Kong: MIT.

Kellogg, R. (1967). *The psychology of children's art*. New York: CRM, Inc.

Kellogg, R. (1970). *Analyzing children's art*. Palo Alto, California: Mayfield.

Kellogg, R. (1973). Misunderstanding Children's Art. *Art Education, 26*(6), 7-9.

Kilpatrick-Louis. (1998). *Encyclopedia of World Biography: 9*. Michigan: Gale Research Inc.

Kisiel, J. (2006). An Examination of Fieldtrip Strategies and Their Implementation within a Natural History Museum. *Science Education, 90*(3), 434-452.

Klingenberg, K. (2009, 31-8-2009). *Meaning Making with Living Animals: How to get from Observation to Evidence?* Paper presented at the ESERA Conference Proceedings, Istanbul.

Krampen, M. (1991). *Children's Drawings: Iconic Coding of the Environment*. London: Plenum.

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education, 14*(1), 23-40.

Kress, G. (1997). *Before Writing. Rethinking the Paths to Literacy*. London: Routledge.

Kress, G. (2010). *Multimodality: A social semiotic appraoch to contemporary communication*. London: Routledge.

Kress, G., & Van Leeuwen, T. (1996). *Reading Images. The Grammer of Visual Design*. London: Routledge.

Kubota, C., & Olstad, R. (1991). Effects of novelty-reducing preparation on exploratory behavior and cognitive learning in a science museum setting. *Journal of Research in Science Teaching, 28*(3), 225-234.

Kupetz, N. B., & Twiest, M. M. (2000). Nature, Literature, and young Children: A Natural Combination. *Young Children, 55*(1), 59-63.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge: Cambridge University Press.

Leach, J., & Scott, P. (2003). Individual and Sociocultural Views of Learning in Science Education. *Science & Education, 12*, 91-113.

Lee, P. C. (2012). The Human Child's Nature Orientation. *Child Development Perspectives, 6*(2), 193-198.

Lemke, J. L. (2001). Articulating Communities: Sociocultural Perspectives on Science Education. *Journal of Research in Science Teaching, 38*(3), 296-316.

Lindsay, G. (2000). Ethical Issues. In A. Lewis & G. Lindsay (Eds.), *Researching children's prespectives*. Buckingham: Open University Press.

Litson, S., & Tunnicliffe, S. D. (2002). Observation or Imagination. *Primary Science Review*(71), 25-27.

Livingstone, P. (2015). Imaginary Places: Museum Visitor Perceptions of Habitat Dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 195-208). London: Springer.

Louv, R. (2008). *Last Child in the Woods*. New York: Algonquin Books.

Lowenfeld, V. (1947). *Creative and mental growth*. New York: MacMillan.

Lowenfeld, V. (1963). *Your Child and His Art*. New York: Macmillan Publishing Company.

Lowenfeld, V., & W.L., B. (1987). *Creative and mental growth* (8th ed.). New Jersey: Prentice-Hall.

Lutts, R. L. (2001). *The Nature Fakers: Wildlife, Science & Sentiment*. New York: University of Virginia Press.

Malchiodi, C. A. (1998). *Understanding Children's Drawings*. New York: The Guilford Press.

Marnadinia, M., & Oliveria, A. D. (2009). Discussing biodiversity in dioramas: A powerful tool to museum education. In S. D. Tunnicliffe & A. Scheersoi (Eds.), The important role of Natural History dioramas in biological learning (Vol. 29, pp. 30-36): ICOM Natural History Committee Newsletter.

Martin, M., Mullis, I., Foy, P., & Stanco, G. (2011). TIMSS 2011 International Results in Science. Amsterdam: TIMSS & PIRLS International Study Center.

Matthews, J. (2003). *Drawing and Painting: children and visual representations* (2nd ed.). London: Paul Chapman Publishing.

Mavers, D. (2003). Communicating meanings through image composition, spatial arragement and links in priamry school student mind maps. In C. Jewitt & G. Kress (Eds.), *Multimodal Literacy* (pp. 19-33). York: Peter Lang.

Mavers, D. (2009). Image in the Multimodal Ensemble. In C. Jewitt (Ed.), *The Routledge Handbook of Multimodal Analysis*. London: Routledge.

Mavers, D. (2011). *Children's Drawing and Writing: The Remarkable in the Unremarkable*. London: Routledge.

MEDE. (2011). A Vision for Science Education in Malta: consultation document. Malta: Ministry of Education.

Medin, D., & Atran, S. (2008). *The Native Mind and the Cultural Construction of Nature*. London: The MIT Press.

Meinig, D. W. (1979). The Beholding Eye. In D. Meining (Ed.), *The Interpretation of Ordinary Landscapes* (pp. 33-48). New York: Oxford University Press.

Melber, L. M., & Abraham, L. M. (2002). Science Education in U.S. Natural History Museums: A Historical Perspective. *Science & Education, 11*, 45–54.

Mendelowitz, D. M. (1953). *Children are Artists*. California: Stanford University Press.

Mergen, B. (2003). Children and Nature in History. *Environmental History, 8*(4), 643-669.

Mitchell, M. L. (2006). Child-Centered? Thinking Critically About Children's Drawings As A Visual Research Method. *Visual Anthropogy Review, 22*(1).

Moran, E. F. (2006). *People and Nature: An Introduction to Human Ecological Relations*. Oxford: Blackwell.

Morris, P. A. (2003). *Rowland Ward: Taxidermist to the World*. Ascot: MPM.

Morris, P. A. (2009). A window on the world – wildlife dioramas. *The important role of Natural History dioramas in biological learning, 29*, 1-40. Retrieved from

Morrow, V., & Richards, M. (1996). The ethics of social research with children: an overview. *Children and Society, 10*(2), 90-105.

Moussouri, T. (1997). The use of children’s drawings as an evaluation tool in the museum. *Museological Review, 4*, 40-49.

Mullis, I., Martin, M., Foy, P., & Arora, A. (2011). TIMSS 2011 International Results in Mathematics. Amsterdam: TIMSS & PIRLS International Study Center.

National Park, S. (2008). General Management Plan Dynamic Sourcebook V. 2.1., from http://planning.nps.gov/GMPSourcebook/Glossary.htm

Nyhart, K. L. (2004). Science, Art, and Authenticity in Natural History Displays. In S. De Chadarevian & N. Hopwood (Eds.), *Models: The Third Dimension of Science*. New York: Stanford University Press.

O'Loughlin, M. (1992). Rethinking Science Education: Beyond Piagetian Constructivism, Toward a Sociocultural Model of Teaching and Learning. *Journal of Research in Science Teaching, 29*(8), 791-820.

OFSTED. (2001). *Out of School Care: Guidance to the National Standards*. Nottingham: DfES.

OFSTED. (2008). Learning outside the classroom: How far should you go? London: OFSTED.

Orion, N., & Hofstein, A. (1994). Factors that Influence Learning during a Scientific Field Trip in a Natural Environment. *Journal of Research in Science Teaching, 31*(10), 1097-1119.

Paddon, H. (2009). The important role of Natural History dioramas in biological learning: Curatorial responses to natural history dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 1-40): ICOM Natural History Committee Newsletter.

Palmer, J. A., Suggate, J., Bajd, B., Hart, P., Ho, R. K. P., Ofwono-Orecho, J. K. W., Peries, M., Robottom, I., Tsaliki, E., Van Staden, C. (1998). An Overview of Significant Influences and Formative Experiences on the Development of Adults. *Environmental Education Research, 4*(4), 445-464.

Palmer, J. A., Suggate, J., Bajd, B., & Tsaliki, E. (1998). Significant Influences on the Development of Adults' Environmental Awareness in the UK, Slovenia and Greece. *Environmental Education Research, 4*(4), 429-444.

Palmer, J. A., Suggate, J., Hart, P., & Robottom, I. (1999). Significant Life Experiences and Formative Influences on the Development of Adults. *Environmental Education Research, 5*(2), 181 — 200.

Paris, S. G. (2002). *Perspectives on Object-Centered Learning in Museums*. London: Lawrence Erlbaum Associates.

Parsons, C., & Breise, A. (2000). Orientation for Self-Guided School Groups on Field Trips. *Visitor Studies Today., 3*(2).

Patrick, P., Byrne, J., Tunnicliffe, S. D., Asunta, T., Carvalho, G., Nuutinen, S. H., . . . Tracana, R. B. (2013). Students (ages 6, 10, and 15 years) in six countries knowledge of animals. *NorDiNa, 9*(1), 18-32.

Patrick, P., Mathews, C., & Tunnicliffe, S. D. (2011). Using a Field Trip Inventory to Determine If Listening to Elementary School Students' Conversations, While on a Zoo Field Trip, Enhances Preservice Teachers' Abilities to Plan Zoo Field Trips. *International Journal of Science Education, 25*(1), 1-25.

Patrick, P., & Tunnicliffe, S. D. (2011). What Plants and Animals Do Early Childhood and Primary Students' Name? Where Do They See Them? *Journal of Sceince Education and Technology, 20*(5), 630-642.

Patrick, P. G. (2006). *Mental Models Students Hold of Zoos*. (PhD), Unpublished PhD Thesis. University of North Carolina, Greensboro.

Peart, B., & Kool, R. (1988). Analysis of a natural history exhibit: are dioramas the answer? *The International Journal of Museum Management and Curatorship, 7*, 117-128.

Peirce, C. S. (1965). Collected papers of Charles Sanders Peirce. In C. Hartshorne, P. Weiss, & W. A. Burks (Eds.), (Vol. I-IV). Cambridge: Harvard University Press.

Phillips, T. (2011). It is approaching breakfast and this is a campervan: weather, drawings and grandparenting in North-West England. *Education 3-13, 39*(2), 107-125.

Piaget, J. (1929). *The child's conception of the world*. London: Routledge and Kegan Paul.

Piaget, J. (1969). *The mechanisms of perception*. New York: Basic Book.

Piaget, J., & Inhelder, B. (1967). *The child's conception of space* (F. J. Langdon & J. L. Lunzer, Trans.). London: Routledge and Kegan Paul.

Pipueras, J., Hamsa, M. K., & Edvall, S. (2008). The practical epistemologies in the museum: A study of students' learning in encounters with dioramas. *Journal of Museum Education, 33*(2), 153-164.

Price, S., & Hein, G. E. (1991). More than a field trip: science programmes for elementary school groups at museums. *International Journal of Science Education., 13*(5), 505-519.

Quinn, S. C. (2006). *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History*. New York: Harry N. Abrams.

Rapp, D. N., & Kurby, C. A. (2008). The 'Ins' and 'Outs' of Learning: Internal Representations and External Visualizations. In J. K. Gilbert (Ed.), *Visualization: Theory and Practice in Science Education* (Vol. 3). London: Springer.

Reiss, M. (2015). The Cultural History and Learning Affordances of Natural History Dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 279-289). London: Springer.

Reiss, M. J., Boulter, C., & Tunnicliffe, S. D. (2007). Seeing the natural world: a tension between pupils' diverse conceptions as revealed by their visual representations and monolithic science lessons. *Visual Communication, 6*(1), 99-114.

Reiss, M. J., & Tunnicliffe, S. D. (1999). Conceptual Development. *Journal of Biological Education, 34*(1).

Reiss, M. J., & Tunnicliffe, S. D. (2001). Students' Understandings of Human Organs and Organ Sytems. *Research in Science Education, 31*, 383-399.

Reiss, M. J., & Tunnicliffe, S. D. (2007). *Opportunities for learning in biology*. Paper presented at the NARST: April 15-17, New Orleans.

Reiss, M. J., Tunnicliffe, S. D., Andersen, A., Bartoszeck, A., Carvalho, G. S., Chen, S., Jarman, R., Jonsson, S., Manokore, V., Marchenko, N., Mulemwa, J., Novikova, T., Otuka, J., Teppa, S., Van Rooy, W. (2002). An International Study of Young Peoples' Drawings of What Is Inside Themselves. *Journal of Biological Education, 36*(2), 58-64.

Robson, S. (2006). Theories of Cognitive Development. *In Developing Thinking and Understanding* (pp. 13-38). London: Routledge.

Rowe, S., & Humphries, S. (2004). The Outdoor Classroom. In M. Braund & M. Reiss (Eds.), *Learning Science Outside the Classroom* (pp. 19-34). London: Routledge Falmer.

Ryan, R., & Deci, E. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Ryan, R., & Deci, E. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist, 55*(1), 68-78.

Ryan, R., & Deci, E. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology, 25*, 54-67.

Ryan, R., & Deci, E. (2002). *Handbook of Self-Determination Research*. University of Rochester Press: Rochester.

Scheersoi, A. (2009). The important role of Natural History dioramas in biological learning: Biological interest development at Natural History dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 1-40): ICOM Natural History Committee.

Scheersoi, A. (2015). Catching the Visitor's Interest. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 145-160). London: Springer.

Scheersoi, A., & Tunnicliffe, S. D. (2009). Editorial. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 2-4): ICOM Natural History Committee.

Schiefele, U. (1991). Interest, Learning and Motivation. *Educational Psychologist, 26*(3 & 4), 299-323.

Schiefele, U. (1992). Topic Interest and Levels of Text Comprehension. In S. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest and development*. Hillsdale, NJ: Erlbaum.

Scott Frisch, N. (2011). Ways of talking about drawing practices. Sociocultural views: Gombrich and visually controlled drawings. *FORMakademisk, 4*(2), 26-37.

Sjøberg, S. (2010). Constructivism and Learning. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International Encyclopedia of Education* (Vol. 5, pp. 485-490). Oxford: Elsevier.

Smidt, S. (2009). *Introducing Vygotsky: a guide for practitioners and students in early years education*. London: Routledge.

Smidt, S. (2011). *Introducing Bruner: a guide for practitioners and students in early years education*. London: Routledge.

Stagno Navarra, K. (2004, 23rd October). EDUKAZZJONI : Gvern-MUT. "Riforma fl-edukazzjoni bi djalogu ma' kulħadd".

Stern, T. (2009). An afternoon among dioramas at Yale Peabody Museum. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 14-15): ICOM Natural History Committee Newsletter.

Storksdieck, M. (2001). Differences in teachers' and students' museum field-trip experiences. *Visitor Studies Today., 4*(1).

Striker, S. (2001). *Young at Art*. New York: Henry Holt and Company.

Stronck, D. R. (1983). The comparative effects of different museum tours on children's attitudes and learning. *Journal of Research in Science Teaching, 20*(4), 283-290.

Sultana, J. (2010) *TV interview with leading Maltese ornithologist Joseph Sultana. Interviewer: S. Balzan*. Reporter, TVM, Malta.

Sultana, J., & Falzon, V. (2002). *Wildlife of the Maltese Islands*. Malta: BDL.

Symington, D. (1981). Children's Drawings of Natural Phenomena. *Research in Science Education, 11*, 44-51.

Tal, R., Bamberger, Y., & Morag, O. (2005). Guided School Visits to Natural History Museums in Israel: Teachers' Roles. *Science Education, 89*(6), 920-935.

Tal, T., & Morag, O. (2007). School Visits to Natural History Museums: Teaching or Enriching? *Journal of Research in Science Teaching., 44*(5), 747-769.

Thomas, G., & Silk, A. (1990). *An Introduction to the Psychology of Children's Drawings*. London: Harvester Wheatsheaf.

Thompson, C. M. (1990). "I make a mark": the significance of talk in young children's artistic development. *Early childhood research quarterly, 5*(2), 215-232.

Tinworth, K. (2015). Relics of the Past + People of the Past = Innovation for the Future: Denver Museum of Nature & Science's Enactor Programm. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 227-242). London: Springer.

Tomkins, S., & Tunnicliffe, S. D. (2001). Looking for Ideas: Observation, Interpretation and Hypothesis-Making by 12-Year-Old Pupils Undertaking Science Investigations. *International Journal of Science Education, 23*(8), 791-813.

Tomkins, S., & Tunnicliffe, S. D. (2006). Bring back the Nature Table! *Environmental Education, 82*, 8-11.

Trowbridge, J., & Mintzes, J. J. (1985). Student's alternative conceptions of animals and animal classification. *School Science and Mathematics, 85*, 304-316.

Trowbridge, J., & Mintzes, J. J. (1988). Alternative conceptions in animal classification: A cross-age study. *Journal of Research in Science Teaching, 25*(7), 547-571.

Trumbull, A. (2006). *Peopling the Powwow: Community Involvement in a Cultural Diorama*. Paper presented at the Connections, Communities and Collections, Miami Beach.

Tunnicliffe, S. D. (1996). Conversations within primary school parties visiting animal specimens in a museum and zoo. *Journal of Biological Education, 30*(2), 130-141.

Tunnicliffe, S. D. (1999, August 8-10). *Science out of school classroom*. Paper presented at the 23rd Annual Meeting of JSSE & JSSE-ICASE-PME International Joint Conference.

Tunnicliffe, S. D. (1999). Stages of a zoo visit. *International Zoo News, 46*(6), 343-346.

Tunnicliffe, S. D. (2000). *Talking about Plants: comments of primary school groups looking at plants as exhibits in a botanical garden*. Paper presented at the BERA, Cardiff.

Tunnicliffe, S. D. (2002). The educational value of natural history collections in learing about biodiversity. *The Biology Curator*(22), 27-40.

Tunnicliffe, S. D. (2005). What do Dioramas Tell Visitors? A Study of the history of Wildlife Diorama at the Museum Of Scotland. *Current Trends in Audience Research and Evaluation., 18*, 23-31.

Tunnicliffe, S. D. (2006). Can your exhibits be interpreted by visitors using more than one sense? *IZE, 23*(1).

Tunnicliffe, S. D. (2006). The Importance of research to biological education. *Journal of Biological Education, 40*(3), 99-100.

Tunnicliffe, S. D. (2007). The potential of natural history dioramas in developing science inquiry. *Gemnews*(Winter), 7.

Tunnicliffe, S. D. (2009). Inquiry at Natural History Dioramas: useful resources in science education. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 16-20): ICOM Natural History Committee Newsletter.

Tunnicliffe, S. D. (2009). Agricultural Dioramas and Natural History: hidden messages? In S. D. Tunnicliffe & A. Scheersoi (Eds.), *The important role of Natural History dioramas in biological learning* (Vol. 29, pp. 36-39): ICOM Natural History Committee Newsletter.

Tunnicliffe, S. D. (2013). Editorial: Animals and plants in natural history dioramas in museums: specimens or objects? *Journal of Biological Education, 47*(4), 189-191.

Tunnicliffe, S. D. (2015). Naming and Narratives at Natural History Dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 161-186). London: Springer.

Tunnicliffe, S. D., Boulter, C. J., & Reiss, M. J. (2007). *Pigeon - friend or foe? Children's understanding of everyday animal*. Paper presented at the BERA Annual Conference, London.

Tunnicliffe, S. D., Gatt, S., Agius, C., & Pizzuto, S. A. (2008). Animals in the lives of young Maltese Children. *Eurasia Journal of Mathematics, Science & Technology Education, 4*(3), 215-221.

Tunnicliffe, S. D., & Laterveer-de Beer, M. (2002). An Interactive Exhibition about Animal Skeletons: Did the Visitors Learn Any Zoology? *Journal of Biological Education, 36*(3), 130-134.

Tunnicliffe, S. D., & Osborne, J. (1995). What do zoos and museums have to offer for learning about animals? *Journal of Education in Museums, 16*, 16-19.

Tunnicliffe, S. D., Osborne, J., & Lucas, A. M. (1997). School visits to zoos and museums: a missed educational opportunity? *International Journal of Science Education, 19*(9), 1039-1056.

Tunnicliffe, S. D., & Reiss, M. (2006). *Drawing breath: the use of drawings and interviews in a six-year longitudinal study of 5-11 year-olds' understandings of what is inside themselves*. Paper presented at the ERIDOB: London.

Tunnicliffe, S. D., & Reiss, M. J. (1999). Building a Model of the Environment: How Do Children See Animals? *Journal of Biological Education, 33*(3), 142-148.

Tunnicliffe, S. D., & Scheersoi, A. (2010). Dusty relics or essential tools for communicating biology? In A. Filippoupoliti (Ed.), *Science Exhibitions: Communication and Evaluation*. Edinburgh: MuseumsETC.

Tunnicliffe, S. D., & Scheersoi, A. (2015). Dioramas as Important Tools in Biological Education. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural History Dioramas: History, Construction and Educational Role* (pp. 133-144). London: Springer.

Vella, V. (2004). Laqgha bejn il-Partit Laburista u l-MUT: Il-MUT b'hafna mistoqsijiet dwar ir-riformi fis-sistema edukattiva. *L-Orizzont*.

Vendramini, D. (2005). Charles Darwin in His Own Words: A pictorial biography. from http://thesecondevolution.com

Ventura, F. (1993). Science and Environmental Education at primary level in Malta: separate interest, different roles. *International Journal of Science Education, 15*(5), 509-519.

Waldrip, B., Prain, V., & Carolan, J. (2006). Learning Junior Secondary Science through Multi-Modal Representations. *Electronic Journal of Science Education., 11*(1).

Wandersee, J. H., & Schussler, E. E. (2001). Toward a theory of plant blindness. *Plant Science Bulletin, 17*(1), 2-9.

Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Wertsch, J. V. (1998). Mediated Action. In W. Bechtel & G. Graham (Eds.), *A Companion to Cognitive Science*. Oxford: Blackwell Publishing.

Wilson, B., & WIlson, M. (1977). An Iconoclastic View of the Imagery Sources in the Drawings of Young People. *Art Education, 30*(1), 4-11.

Wilson, B., & Wilson, M. (1979). Figure Structure, Figure Action and Family in Drawings by American and Egyptian Children. *Studies in Art Education, 21*(1), 36-43.

Wonders, K. (1993). *Habitat Dioramas: Illusions of Wilderness in Museums of Natural History*. Uppsala: Almqvist & Wiksell.

Wonders, K. (2003). Habitat Dioramas and the Issue of Nativeness. *Landscape Research, 28*(1), 89-100.

Wright, S. (2010). *Understanding Creativity in Early Childhood: meaning-making and children's Drawing*. London: Sage.

Appendix

Institute of Education, University of London

Ethics Approval for Doctoral Student Research Projects: Data Sheet

Please read the notes before completing the form

Project title	The visual impact of wildlife dioramas on primary school children and its expression in their drawing and talk.		
Student Name	Edward Mifsud		
Supervisor	Ralph Levinson and Sue Dale Tunnicliffe		
Advisory committee members			
School/Unit	Maths, Science & Tech.	Faculty	FCP
Intended start date of data collection	12/11/2007		
Funder	None		
Professional Ethics code used	BERA		

Has this project been considered by another (external) Research Ethics Committee?

If your research is based in another institution then you may be required to submit your research to that institution's ethics review process. If your research involves patients or staff recruited through the NHS then you will need to apply for ethics approval through an NHS Local Research Ethics Committee. In either of these cases, you don't need ethics approval from the Institute of Education. If you have gained ethics approval elsewhere, please detail it here:

None

Research participants

Does the research involve human participants?

☒ Yes, as a primary source of data *(e.g. through interviews)*

☐ Yes, as a secondary source of data (e.g. using existing data sets)

☐ No *Please explain*____ ________________________________

If the research involves human participants, who are they? (tick all that apply)

☐ Early years/pre-school

☒ School-aged children

☐ Young people aged 17-18

☐ Unknown

☐ Adults *please describe them below*

8 year olds in the 4th grade of primary school in Malta.

Research methods to be used (tick all that apply – this information will be recorded on a database of the types of work being presented to Ethics Committees)

- ☐ Interviews
- ☐ Focus groups
- ☐ Questionnaire
- ☐ Action research
- ☒ Observation
- ☒ Other Drawings
- ☐ Systematic review
- ☐ Randomised controlled trial
- ☐ Literature review
- ☐ Use of personal records

Institute of Education, University of London

Ethics Approval for Doctoral Student Research Projects:
Planned Research and Ethical considerations.

1. Summary of planned research (please indicate the purpose of the research, its aims, main research questions, and research design. It's expected that this will take approx. 200–300 words, though you may write more if you feel it is necessary).

The rationale of the study is to investigate what children notice and remember about animals and plants from direct observation, and use findings to help schools, museums and nature parks design their educational program.

The aim of the study is to gain insight into children's understandings of animals and plants, habitats and human constructed artefacts through observations of new dioramas of Maltese habitats at the Natural History Museum.

The research questions are:
What is the visual impact of wildlife dioramas on primary school children and how is this expressed in their drawing?
Will there be any differences between the drawings before seeing the dioramas and the drawings after?
What do they remember from what they have seen?

Research Design
The theoretical framework draws on Constructivism, informal learning and out-of-school learning. Two year 4 classes from two different schools will be involved. The children are mixed ability 7-8 year olds from middle class families. I will conduct all data collection acting as an outsider researcher. I will visit the schools prior to planned activities to talk to the children and familiarise myself with them and them with me. The day before the museum visit, children will be asked to draw what they think they will be seeing. A protocol will be used to guide the process. At the museum, children will be split into small groups of 2 or 3 and they will see the dioramas in these groups. They will be allowed to talk, with minimal cueing from my part to get them started and extract information. All converstions will be recorded using an MP4 device and will be used to cross-reference with the drawings and find out what and how much they notice in the dioramas. The day following the visit, the children will be asked to draw what they had seen at the museum visit. The pre- and post-visit drawings will be coded, analysed and compared to find differences that might occur. Analysis will be based on categories that will be evident in the drawings with the aim of producing a quantitative result using a systemic system. A qualitative analysis will also be included.

2. Specific ethical issues

(Outline the main ethical issues which may arise in the course of this research, and how they will be addressed. It's expected that this will require approx. 200–300 words, though you may write more if you feel it is necessary. You will find information in the notes about answering this question).

The participants of this study are children 7 to 8 years old. They research will be done by me as the researcher in the presence of the class teacher and teaching assistants.

The study is expected to provide valuable information that will help schools and authorities design more effective science education program. The children are the main subjects to benefit from this, while teachers will be able to provide more interesting and enriching science experiences to their classes.

There is a risk that, as an outsider, I might not be completely accepted by the children and they might feel uneasy in my presence. I will bank on my experience as a teacher and will go to the schools to make myself familiar with the children.
I will seek the permission of the class teachers, the head teachers and the LEAs where this is warranted and especially in the light of the Data Protection Act.
I will also seek written formal consent from the parents using an appropriate printed leaflet that will be given to each child prior to the start of the research. The children will return a section of the leaflet either consenting or refusing to participate. Only children whose parents consent will be included in the study. These will be kept by the school. The leaflet will also provide information about the project. No incentives of any form will be offered. Children will be free to withdraw at any time.

All data will be kept by me and will only be shown to the supervisors. Any names will be changed in case of dissemination of parts of data. Recording will only be used to obtain conversational data during the visit. These will be heard and transcribed by me and any particular piece of conversation that might be used in a report will be anonymised by changing the names. Participants will be promised full anonymity.

The findings will be used for the MOE2 assignment, will be seen by the supervisors and will be forwarded to the school head teachers.

3. Attachments

Please attach the following items to this form:
The proposal or project outline for the project
Approval letter from external Research Ethics Committee, if applicable
Where available, information sheets and other materials to be used to inform potential participants about the research.

4. Declaration

I confirm that to the best of my knowledge this is a full description of the ethics issues that may arise in the course of this project			
Signed		Date	

School Use

Date considered:

Approved and reported to FREC ☐

Referred back to applicant and supervisor ☐

Referred on to FREC ☐

Signature of Supervisor: ....

Signature of Advisory committee member: ....

FREC use

Date considered:......................

FREC reference:............

Approved and filed ☐

Referred back to applicant ☐

Referred to RGEC ☐

Signature of Chair of FREC:...

Institute of Education, University of London

Ethics Approval for Doctoral Student Research Projects: Data Sheet

Please read the notes before completing the form

Project title	The influence of dioramas on children's representations of wildlife as reflected by their drawing.		
Student Name	Edward Mifsud		
Supervisor	Sue Dale Tunnicliffe and Ralph Levinson		
Advisory committee members			
School/Unit	GEMS	Faculty	FCP
Intended start date of data collection	01/10/2009		
Funder	None		
Professional Ethics code used	BERA		

Has this project been considered by another (external) Research Ethics Committee?
If your research is based in another institution then you may be required to submit your research to that institution's ethics review process. If your research involves patients or staff recruited through the NHS then you will need to apply for ethics approval through an NHS Local Research Ethics Committee. In either of these cases, you don't need ethics approval from the Institute of Education. If you have gained ethics approval elsewhere, please detail it here:

None

Research participants

Does the research involve human participants?

☒ Yes, as a primary source of data *(e.g. through interviews)*

☐ Yes, as a secondary source of data (e.g. using existing data sets)

☐ No *Please explain*____ ____

If the research involves human participants, who are they? (tick all that apply)

☐ Early years/pre-school

☒ School-aged children

☐ Young people aged 17-18

☐ Unknown

☐ Adults *please describe them below*

9 year old in 5th grade of primary education in Malta

Research methods to be used (tick all that apply – this information will be recorded on a database of the types of work being presented to Ethics Committees)

- ☒ Interviews
- ☐ Focus groups
- ☐ Questionnaire
- ☐ Action research
- ☒ Observation
- ☒ Other Drawings and Mind Maps (as in Personal Meaning Mapping)
- ☐ Systematic review
- ☐ Randomised controlled trial
- ☐ Literature review
- ☐ Use of personal records

Institute of Education, University of London

Ethics Approval for Doctoral Student Research Projects:

Planned Research and Ethical considerations.

1. Summary of planned research (please indicate the purpose of the research, its aims, main research questions, and research design. It's expected that this will take approx. 200–300 words, though you may write more if you feel it is necessary).

The rationale of the study is to gain insights into what children notice and remember about animals and plants from direct observation of in out of school settings and to use the findings to help schools, museums and science centres design effective educational program in Biological Science.

The aim of the research is to investigate what captures the attention of children while viewing habitat dioramas at the Natural History Museum in Malta. How much do they know about local wildlife before they visit the museum? Which features of the dioramas do they remember best? How much will they remember after four weeks?

The main research question is:

How do dioramas influence children's representations of wildlife as reflected by their drawing?

Research Design

The theoretical framework draws on constructivism, socio-cultural theory, semiotics, mental imaging, informal learning and musuem learning. The research involves 8-9 year old school children of mixed ability in state primary schools. The methodology is essentially a experimental design, pre-, post-testing with an control group. The data collected are conversations, drawings and mind maps that allows for triangulation. The control and treatment groups undergo the pre-visit exercise. The treatment group visit the NHM and an immediate post-visit exercise carried out. Four weeks following the visit a second post-visit exercise will be conducted with both groups. Data collected will be: drawings, mind maps and conversations. Children will also be interviewed about the drawings. The pre- and post-visit drawings will be coded, analysed and compared to find differences that might occur. Analysis will be based on categories that will be evident in the drawings with the aim of producing a quantitative result using a systemic system. A qualitative analysis will also be included.

2. Specific ethical issues

(Outline the main ethical issues which may arise in the course of this research, and how they will be addressed. It's expected that this will require approx. 200–300 words, though you may write more if you feel it is necessary. You will find information in the notes about answering this question)

The participants of this study are children 9 to 10 years old. The research will be carried out by myself as the researcher in the presence of the class teacher and teaching assistants.

The study is expected to provide valuable information that will help schools and authorities design more effective out-of-school science education field trips. The children are the main subjects to benefit from this, while teachers will be able to provide more interesting and enriching science experiences to their classes.

There is a risk that, as an outsider, I might not be completely accepted by the children and they might feel uneasy in my pesence. I will bank on my experience as a teacher and will go to the schools to make myself familiar with the children.
I will seek the permission of the class teachers, the headteachers and the LEAs where this is warranted and especially in the light of the Data Protection Act.
I will also seek written formal consent from the parents using an appropriate printed leaflet that will be given to each child prior to the start of the research. The children will return a section of the leaflet either consenting or refusing to participate and these forms will be held by the school administration. Only children whose parents consent will be included in the study. The leaflet will also provide information about the project. No incentives of any form will be offered. Children will be free to withdraw from the project at any time.

All data will be kept by me and will only be shown to the supervisors. Any names will be changed in case of dissemination of parts of data. Recording will only be used to obtain conversational data during the visit. These will be heard and transcribed by me and any particular piece of conversation that might be used in a report will be anonymised by changing the names. All audio recorded data will be destroyed when the research is finished. Participants will be promised full anonymity.

The findings will be seen by the supervisors, included in the PhD thesis and a report will be forwarded to the school administration and LEA.

3. Attachments

Please attach the following items to this form:
The proposal or project outline for the project
Approval letter from external Research Ethics Committee, if applicable
Where available, information sheets and other materials to be used to inform potential participants about the research.

4. Declaration

I confirm that to the best of my knowledge this is a full description of the ethics issues that may arise in the course of this project			
Signed		Date	

School Use

Date considered:

Approved and reported to FREC ☐

Referred back to applicant and supervisor ☐

Referred on to FREC ☐

Signature of Supervisor: ....

Signature of Advisory committee member: ....

FREC use

Date considered:......................

FREC reference:............

Approved and filed ☐

Referred back to applicant ☐

Referred to RGEC ☐

Signature of Chair of FREC:..

3. Attachments

Please attach the following items to this form:

- The proposal or project outline for the project
- Approval letter from external Research Ethics Committee, if applicable
- Where available, information sheets and other materials to be used to inform potential participants about the research.

4. Declaration

I confirm that to the best of my knowledge this is a full description of the ethics issues that may arise in the course of this project			
Signed		Date	17-7-09

School Use

Date considered: 28.07.09

Approved and reported to FREC ☐

Referred back to applicant and supervisor ☐

Referred on to FREC ☐

Signature of Supervisor: ....

Signature of Advisory committee member: ....

FREC use

Date considered:......................

FREC reference:............

Approved and filed ☐

Referred back to applicant ☐

Referred to RGEC ☐

Signature of Chair of FREC:..

Direttorat Ghal Servizzi
Edukattivi, Il-Furjana
VLT 2000

Directorate for
Educational Services
Floriana, VLT 2000

Request for Research in State Schools

A. (Please use BLOCK LETTERS)

Surname: MIFSUD Name: EDWARD

I.D. Card Number: 31269 M Telephone: 21454291

Address: LEPORELLO, 112, TRIQ SAN TROFIMU
RABAT. Post Code RBT 2226

E-mail Address: EDWARD.MIFSUD@EDUC.GOV.MT

Faculty. GEMS Course: PHD Year Ending: 2010

Area/s of research: MUSEUM LEARNING / WILDLIFE / PRIMARY SCIENCE

Aims of research: (Underline as appropriate) Long Essay Dissertation Thesis Publication

Estimated duration of research: 6 HOURS / SCHOOL Language used: MALTESE

Description of method to be used: PRE / POST MUSEUM VISIT DRAWING.
MUSEUM WORKSHEET, *UNSTRUCTURED INTERVIEW ON DRAWING

School/s where research is to be carried out: RABAT PRIMARY
LIJA PRIMARY LUQA PRIMARY

Years / ~~Forms~~: 4 - 5 Age range of students: 7-8 YEARS

I accept to abide by the rules and regulations re Research in State Schools and to comply with the Data Protection Act 2001.
Warning to applicants – Any false statement, misrepresentation of concealment of material fact on this form or any document presented in support of this application may be grounds for criminal prosecution.

Signature of applicant .... Date: 30 / 3 / 2009

* General questions on what is drawn will be asked to clarify the content of the drawings.

B. Tutor's Approval (where applicable)

The above research work is being carried out under my supervision.

Tutor's Name: RALPH LEVINSON Signature .... Official Stamp
(in block letters)

Institute of Education
20 Bedford Way
London WC1H 0AL

C. Directorate for Educational Services – Official Approval

The above request for permission to carry out research in State Schools is hereby approved according to the official rules and regulations.

Raymond Camilleri
Assistant Director Research & Planning

Assistant Director
(Research & Planning)

Date: 07/04/09 Official Stamp

Conditions for the approval of a request by a student to carry out research work in State Schools

Permission for research in State Schools is subject to the following conditions:

1 The official request form is to be accompanied by a copy of the questionnaire and / or any relevant material intended for use in schools during research work.
2 The original request form, showing the relevant signatures and approval, must be presented to the Head of School.
3 All research work is carried out at the discretion of the relative Head of School and subject to their conditions.
4 Researchers are to observe strict confidentiality at all times.
5 The Directorate for Educational Services reserves the right to withdraw permission to carry out research in State Schools at any time and without prior notice.
6 Students are expected to restrict their research to a minimum of students / teachers / administrators / schools, and to avoid any waste of time during their visits to schools.
7 As soon as the research in question is completed, the Directorate for Educational Services assumes the right to a full copy (in print /on C.D.) of the research work carried out in State Schools. **Researchers are to forward the copies to the Assistant Director Research and Planning, Directorate for Educational Services.**
8 Researchers are to hand a copy of their Research in print or on C.D. to the relative School/s.
9 In the case of video recordings, researchers have to obtain prior permission from the Head of School and the teacher of the class concerned. Any adults recognisable in the video are to give their explicit consent. Parents of students recognisable in the video are also to be requested to approve that their siblings may be video-recorded. Two copies of the consent forms are necessary, one copy is to be deposited with the Head of school, and the other copy is to accompany the Request Form for Research in State Schools. Once the video recording is completed, one copy of the videotape is to be forwarded to the Head of school. The Directorate for Educational Services reserves the right to request another copy.

The Dioramas

IOE LONDON
Leading education and social research
Institute of Education
University of London

Edward Mifsud

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Leporello, 112
Triq San Trofimu
Rabat. RBT 2226

Tel: 21454529l
Mob: 79805006
Email: emifsud@ioe.ac.uk

Wildlife in Children's World

Learning to Care and Preserve

A Research Project

Why is the research being done?

You certainly appreciate that the quality of science education of your child is of primary importance. This project is aimed at improving the quality of science that children do in Maltese primary schools. The children's awareness of plants and animals is the first step toward their appreciation of wildlife. Their experiences in places that display animals and plants is one way of enhancing this awareness. I plan to listen to and observe children while they look at animals in their natural setting at the Natural History Museum in Mdina. They will also have the opportunity to express themselves in drawing.

In this research project I aim to answer the following questions:

- What is the value of exhibits in Natural History Museum to the learning about wildlife?
- What do children learn really note when they observe wildlife exhibits?
- What type of mental model is formed?
- How is this expressed in their drawing?

Who will participate in this project?

The participants will be your child and the rest of the class together with other pupils in the same year from other schools, who will be visiting the Museum on separate days. I will be doing all the data collection with the required assistance from class teacher.

Does your child have to take part?

It is entirely up to you to decide whether you would like your son or daughter to take part.

If your son or daughter does not want to take part, please DO NOT force them to do so.

You and your child are free to withdraw from the project at any time you wish.

You can choose to opt-out using this form.

Who will see the data?

I am fully responsible for the safe storage of all information, drawings and recordings.

No one needs to be identified and if the name or identity of a child incidentally shows, it will be concealed in any published material.

The school will not be forwarded copies of data, but only copies of reports on request by the administration.

About the researcher

Who am I?

I am a Biology lecturer at the University of Malta Junior College. Previously I thought Biology, Chemistry and Science at Giovanni Curmi Higher Secondary and Hamrun Boys JL.

I am reading for a doctorate at the Institute of Education in the University of London. My research interest is out-of-school learning, primary science education and museum learning with a focus on wildlife and environmental science. I participated and presented my research at conferences in Malta, Dijon (France) and Utrecht (Netherlands).

I plan to finish and present my PhD thesis by 2011 and with your help this will be possible.

Consent Form

I ______________________________,

parent/guardian of ________________

give/refuse my consent to Edward Mifsud to conduct his research with my child. I also reserve the right to withdraw from the project at any time.

Date ______________________________

Signature __________________________

Child's Drawing Content – Museum Task

SCHOOL: Rabat Primary B	**NAME:**	**AGE:**
CLASS:	**DATE:**	**REF:**

CHILD'S EXPLANATION	
Pre-diorama drawing	**Diorama drawing**
Scene or Subject:	Scene or Subject:
Animals:	Animals:
Plants:	Plants:
Physical:	Physical:
Reason for choice:	Reason for choice:
Influences and other observations:	Influences and other observations:

Interview with NHM curator: John J Borg
Monday 17th May, 2010.

1. When were the dioramas installed and whose idea as it?
2. Considering that they aren't so fashionable in Europe, why was the need felt to install the dioramas?
3. Who was responsible for their construction and how were decisions taken?
4. Why did you choose these particular settings and why choose local settings?
5. Did you consult or follow any techniques or models to build these settings?
6. Why didn't you include any signage plaques or any other effects such as sound?
7. What problems did you encounter while constructing the settings?
8. a. Was there an educational rationale behind the settings?

   b. What message are you trying to convey to visits?

   c. What type of visitor did you have in mind?

   d. Don't you think that, had you pursued your idea, the intended message of the dioramas would have been somewhat different?
9. Are there any planned educational programs at the NHM?
10. Did you plan for any educational activities at the dioramas?
11. Have you assessed the effectiveness of the settings yet? Was any research conducted at the NHM and particularly the dioramas?
12. What future plans are there, if any, as regards dioramas?
13. Do you want to add anything else?

Development progression from Class, Pre-diorama to Diorama

Pupil Name	Development through drawings
J Balzan	Only one butterfly in class drawing. No real relationship between humans, birds and physical objects in pre-diorama drawing, no evident story told. The bird on the tree is decontextualized. The diorama drawing shows the sand dune, with clear relationship between birds, another feed and a third in flight. The habitat is clearly shown here and the diorama has helped the student to place the organisms with greater accuracy. Pupil seems to have acquired the narrative in the setting. Birds and plants drawn in iconic mode, while humans disappear in the diorama.
P Borg	From decontextualized animals in the class drawing to ecological interactions in other drawings, pre-diorama and diorama drawings very colourful, woods drawn first with bird and butterfly well placed in the habitat with a human in the foreground. Diorama is the equally represented sand dune, with only two birds, one flying i.e. in action and sun inserted. Birds, trees and human drawn in iconic mode, but to scale in diorama drawing as opposed to previous. Pupil acquired the narrative in the setting.
J Bouzguenda	Only decontextualized animals in class drawing, only one bird drawn out of scale but in context in the pre-diorama drawing, ecological interactions in diorama drawings, with bird on tree and rabbit on ground both drawn to scale. Pupil partially acquired the narrative in the setting. Animals, trees in iconic mode.
N Camilleri	In class drawing only hamster and tree, in pre-diorama more organisms and human in context. The diorama drawing shows the sand dune, with no evident ecological interaction between birds. Animals shown in flight in both. The habitat is clearly shown here and the diorama has helped the student to place the organisms with greater accuracy. Pupil seems to have acquired the narrative in the setting. Birds and plants drawn in iconic mode, while humans disappear and sun is inserted in the diorama.
R Camilleri	Only one tree in class drawing, other two drawings are very poor, with no context, diorama just shows one bird, but with very little elaboration.
N Caruana	Only decontextualized animals in class drawing, pre-diorama drawing is basic, with some context while in diorama items in context and with some perspective too. Accuracy of habitat representation and in placement of organisms in habitat. Animals in iconic mode, plants more realistic in diorama drawings.
K D'Anastas	Class drawing with only one bird and pre-drawing shows only two elaborately drawn parrots, in both cases decontextualized. Diorama is a conflation of field and bastion with the same iconically drawn parrot inserted in the setting. Here the parrot is now contextualised with a habitat now clearly show.

D Diedo	The class drawing shows some context, pre-drawing not showing any real narrative, with an oversized very well drawn bird in the center not connected with the rest. There is a **hunter** shooting at a bird on the iconic drawn tree. The diorama shows a habitat with few animals and no plants, but changes from charismatic pheasant to non-charismatic shrew, beetle and small bird and hunter now absent.
G Fenech	Drawings show inconic decontextualized animals and plants, with just a hint of context, but no real semblance to the setting.
Ch Galea	Class drawing shows iconic snail and trees with in context, but just one bird in pre-drawing. The diorama drawing shows the sand dune, with no evident ecological interaction between birds. Animals shown in flight in both. The habitat is clearly shown here and the diorama has helped the student to place the organisms with greater accuracy. Some perspective shown too.
T Incorvaia	Only decontextualized animals seen in class drawing. In pre-diorama drawing shows **hunter** shooting at bird, no habitat shown but pupil included a 'no hunting' sign evidencing animal welfare and environmental concern. Diorama drawing roughly shows the house yard, with animals oversized and no perspective. There is a positive aspect in being able to construct a habitat, but welfare aspect is lost and no proportion in size seen.
A Muscat	Class and pre-diorama drawings only show decontextualized animals and plants, with a very rough and basic diorama drawing.
Ch Muscat	Only decontextualized animals seen in class drawing and drawn in colour. Just a bird in pre-diorama and a duck in post, both decontextualized.
MJ Scerri	Just a single parrot in class, a bird in pre-diorama and a duck in diorama drawing all decontextualized.
H Schembri	Only decontextualized animals seen in class drawing. No particular narrative noted in pre-diorama drawing with organisms in context. The diorama drawing shows the house yard, with more animals and perspective. The habitat is clearly shown here and the diorama has helped the student to place the organisms with greater accuracy. Pupil seems to have acquired the narrative in the setting. Birds drawn in iconic mode, while plants are much more realistic.
MC Vella	In class and pre-drawing only decontextualized birds shown. Diorama drawing shows the field with most of the animals present in the setting drawn in proportion and perspective shown. Setting has helped the student to place the organisms with greater accuracy in the habitat. Pupil seems to have acquired the narrative in the setting. Animals in iconic mode.
J Zahra	Only one oversized snail in class drawing, a hint of a garden in pre-diorama while diorama only shows a boat.

E Zerafa	Only two skeletons in class drawing and a bird/egg in the pre-diorama drawing with no evident context. In diorama drawing, field habitat is clear with more animals and in context, perspective shown. Animals in iconic mode.
MJ Agius	Class drawing was is a colourful wood with bird in context, but next two only showing decontextualized birds drawn quite accurately.
L Borg	Class and pre-diorama drawings are very similar, first in colour and shows the charismatic Lion, second not in colour. Diorama drawing shows V-shaped birds and iconic butterflies, quite a few iconic flowers and trees, with no perspective shown.
S Borg	Class drawing shows a landscape with just one tree and the iconic house, hills and sun. Pre-diorama drawing shows a habitat with birds and butterflies in context all drawn in iconic mode. Habitat seen in diorama drawing shows iconic butterflies and snails, and flowers and trees all drawn in iconic mode. No perspective shown.
C Camilleri	First drawing shows a colourful composition with various birds, ants, dog and humans including a hunter. Breeding also shown with birds nesting. In second drawing decontextualized birds, horse and tree shown, while in third an oversized flying bird, beetle, shrew, rooster and 3 trees all in iconic mode. Overall decremental in knowledge.
M Cortis	First drawing shows decontextualized animals and plants, with more context in second and also the third although both very basic and with no colour. Animals and plants all in iconic mode in three drawings.
S Galea	First drawing shows a wide variety of animals and some plants too, but less variety in second, with only one flower. Third drawing shows only two birds, which are now in context but overall there was a reduction in biodiversity. All organisms drawn in iconic mode.
A M Gauci	Only decontextualized organisms shown, but with reduced numbers from first to third drawing.
M Gauci	The first drawing shows a conflation of a field and valley, totally different in the second and field in third similar to first drawing. Only difference more plants and flowers in third drawing compared to other two but no animals.
C Lucasenco	First drawing shows a garden, colourful iconic trees, birds and butterflies in context; few birds, trees and flowers in second but in third drawing there is a clear habitat with animals placed with greater accuracy and in perspective.
F Marchand	Three animals and hunter in first drawing to just one in second and three in the third but less elaborated and less accurate.
J Micallef	Animals and plants decontextualized in first drawing, same thing noted in second but with reduced diversity, while in third animals are in context and placed with greater accuracy and with increased accuracy of habitat representation. Perspective not shown.

M Mifsud	Various contextualized vertebrates and invertebrates, with feeding and reproduction shown in first and in colour. This changed to just two decontextualized birds in the second and just the rooster in third.
Max Mifsud	Colourful trees, flowers, birds and butterflies in first drawing in context. In second drawing only 3 isolated birds, while third shows the sand dune with low elaboration.
P Mohamed	Various contextualized vertebrates and invertebrates, with breeding and people fishing in first. This changed to fewer animals in the second and just one bird in third.
M Muscat	Various contextualized vertebrates and invertebrates, with breeding and person fishing in first. This changed to only three animals in the second, and one bird and 2 rabbits in third. *First drawing of this pupil is very similar to the previous, indicating that they copied.*
M Powell	Only one bird in context in first and second, while there are two birds and rabbit in the third. First drawing bird accurately drawn, others in iconic mode.
E Scerri	Highly elaborate class drawing showing flying birds, breeding bird, ducks and fish, with a strong sense of perspective and colour. This transformed to decontextualized birds drawn in greater detail in the pre-diorama and just three birds in diorama with no perspective.
C Schembri	Class and pre-diorama just show the pupil and her brother flanked by two threes which transformed into a picture showing decontextualized animals, flowers and the sand dune boat. The diorama helped her to focus on drawing animals albeit not in context.
B Smith	Class drawing shows an elaborate picture of a beach with a very accurately drawn palm, a bird and a duck and a beach umbrella, but conflated with domestic animals. This transformed into a single decontextualized very accurately drawn crow and eventually into a habitat (house yard), showing that the pupil moved from the imaginative class drawing to the actual typical house yard habitat.
JP Zahra	Class drawing is an imaginative composition showing a conflation of ideas with no clear context and including human stick figures, birds (V-shaped) and one iconic fish. Pre-diorama shows just one iconically drawn crow and the diorama drawing shows a more organised field picture showing mainly flowers in rows. Diorama helped this student to draw a more coherent picture focused on one habitat.
L Bartolo	Class and pre-diorama are two very similar imaginative drawings, very colourful with some degree of perspective, an oversized butterfly in the center, but presented in context. There are fewer animals and flowers in the pre-diorama drawing, while diorama drawing is in perspective, with butterflies and rooster in proportion to plants. In this case too, pupil moved from an imaginative mode to a realistic mode, but with reduced

	variety and richness in organisms.
A Borda	The class drawing is colourful, imaginative with perspective and showing breeding relationship, with a human in the center. Transforms to an isolated bird in the pre-diorama and eventually into a partially represented 'house yard' with no perspective and oversized butterfly and rooster.
M Borg	Class and pre-diorama show iconic bees, butterflies, trees and flowers in context and in colour with a rare anthropomorphic sun. This transforms into a colourless partial field representation with just three animals, drawn inaccurately with an anthropomorphic rabbit. Generally there is no significant change and this is one of few pupils that show anthropomorphism in their drawings.
E Briffa	Class shows some birds in context, but one caged and pre-diorama shows more animals in context and better scale, while diorama shows better scaling, context and perspective. All organisms iconic.
N Bugeja	Class and pre-diorama drawings show an isolated rabbit and a bird accurately done, but both decontextualized. The diorama drawing is a partially represented sand dune showing that the pupils tried to represent a habitat with animals in context, with boat dominating the picture.
P Buhagiar	Class drawing shows snakes somewhat isolated from the rest of features, with iconic plants but drawn differently from the other children perhaps because he is of Asian origin. Snakes and the sun are anthropomorphic. Pre-diorama shows more context and narrative, but animals are oversized, non-iconic and no colour shown. Diorama shows part of the 'house yard' with birds in context.
D Chetcuti	Class and pre-diorama show quite similarly represented animals and plants, with an **unusual** 2nd drawing showing higher diversity, iconically represented with anthropomorphic animals and sun. Diorama drawing loses colour, elaboration and perspective, with fewer animals, but anthropomorphism persists.
F Chircop	Highly elaborate and colourful class drawing showing a girl, similar pre-diorama drawing, but with fewer animals, human dropped and an anthropomorphic sun included. This transforms into diorama drawing with no perspective, with just the gecko and grass included.
K Farrugia	Class drawing colourful only a dog in a not so clear context, two animals in the pre-diorama in clearer context transformed into a partial 'house yard' with no colour and only few plants shown. Clear decrement occurred toward 3rd drawing.
K Gatt	Class drawing in context with two humans shown, increment in diversity in pre-diorama yet again humans disappear and further increment in diorama which has a conflation of different diorama settings. One of the **rare cases** with consistent knowledge enhancement through out the three drawings.

K Gauci	Class and pre-diorama drawings equally elaborate and colourful with different focus but similar iconic animals and trees. Vertebrates (fish) centrally placed in the 1st compared to invertebrates (butterfly and bees) and an anthropomorphic sun in the 2nd drawing. Diorama is a very partial 'field' with no colour and just a bird and an anthropomorphic rabbit.
G Giordmaina	Almost identical class and pre-diorama drawings. A very basic 'sand dune' with just 2 birds, reed and boat.
M Grech	Similar class and pre-diorama drawings, with slight decrement in diorama drawing.
A Micallef	Colourful and highly elaborate class drawing, showing a forest with charismatic animals such the eagle, cobra, cheetah, similar pre-diorama drawing but reduced number of trees and shift to non-charismatic animals e.g. moth. Transformed into 'bastion' habitat, showing the non-charismatic local fauna, accurately drawn palm and with greater perspective. Beans can was included in this drawing.
J Muscat	Class drawing with no real narrative five ducks isolated from two trees shown a saprophytic relationship with mushrooms. Context appears in pre-diorama drawing with more accurate charismatic birds conflated in a local habitat (Dingli Cliffs) showing the rock strata of the Maltese Islands. This transformed to 'sand dune' with many birds (now iconic) showing feeding relationships but accuracy lost and oversized. One of few pupils that coloured the three drawings.
L Portelli	Class drawing shows a deep sea habitat elaborately drawn, reduced to just two decontextualized birds in pre-diorama and a diorama drawing with reduced elaboration and some perspective.
C Sant	Class and pre-diorama show colourful and iconic habitats (mountains) with increased diversity and ecological relationships in the 2nd drawing and finally an also coloured bastion, well elaborated but now showing a local habitat from two foreign habitats (waterfall and mountains).
M Scerri	Class drawing with colourful iconic animals and plants, to pre-diorama drawing with just a pelican and swordfish (charismatic) and eventually a well-elaborated bastion with little perspective and colourless.
M Tonna	Class and pre-diorama drawings with unclear context and few animals transformed to well-elaborated sand dune with all items shown but animals in iconic mode.

CLASS 5.1	Drawing 1			Drawing 2			Drawing 3					Relation to Diorama			Graphical Features			Development Change		
Student Name	**Animal**	**Plant**	**Scale**	**Animal**	**Plant**	**Scale**	**Animal**	**Favourite**	**Plant**	**Scale**	**External**	**In position**	**Variants**	**Omitted**	**Iconic Mode**	**Colour**	**Accuracy**	**More Variety & Habitat Representation**	**Better Organism**	**Less Habitat & Variety Representation**
Balzan James	Butterfly	Sandarac (Gharghar)	Butterfly OFS	**Field**: Bird on three, bird **flying** and owl on tree **C.**	None	Bird IS, **Antrop**	**Sand dune**: bird **flying**, bird on boat, 2 birds on sand **C**, bird on stone.	Field: diff	Reed	Bird/boat OFS	None	All Birds	Bird/stone in opp dir.	bird/reed	Birds similar:D2,D3	None	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen.		
Borg Paolo	2 Birds, cat, dog, snail, ostrich	2 trees	All OFS, **Antrop**	**Woods**: Bird on tree **C**, butterfly, himself.	2 apple trees, other tree	Bird OFS	**Sand dune**: bird **flying**, bird on boat.	Yes, also field	Reed	Birds IS	Sun	All Birds	flying bird opp dir, reed ifo boat not behind, fish bone on R not on L	bird/sand, bird/stone, bird/reed.	Bird similar: D2,D3	D2,D3	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen.		
Bouzguenda Josef	Butterfly, duck, shark, snail, jelly fish	None	All OFS, **Antrop**	**Garden**: One bird **C**, **nesting**.	Tree	Bird OFS	**Field**: Bird/tree, Rabbit **C**	Others too difficult	Tree	All IS	Clouds	All	None	9 birds, chameleon, skink	Bird similar: D2,D3	D2,D3	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Partial narrative seen.		
Camilleri Natalie	Hamster	Tree	All OFS	**Garden**: 2 butterflies **flying**, bird **flying**, girl **C**	Tree, flowers	Bird OFS, 2 Butterflies OFS, **Antrop**	**Sand Dune**: Bird **flying C**, bird/boat, bird/sand	Yes	Reed	All IS	Sun	All	flying bird opp dir, reed ifo boat not behind, bird/boat front looking	3 birds	Birds similar:D2,D3	D2	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen.		
Camilleri Rebekah	None	Tree	N/A	**Garden**: none	Tree	Isolated	**Bastion**: bird, nest	Yard	Tree	Birds IS	Sun, nest	All	None	Owl, Bat, Weasel, Rat, bird, moth.	Tree similar	None	L		From no animals to bird/nest	
Caruana Nell	2 Butterfly, eagle, owl,fish, dolphin, crab, jellyfish	plant	All OFS, **Antrop**	**Field**:birds **flying**, bird on tree, snail, worm	2 trees	Bird IS	**Yard**: 6 birds, butterflies, gecko	Yes	2 creepers, flowers	Birds IS	none	All	None	Bird/tree	Bird similar: D2,D3	None	H:D3	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen.		
D'Anastas Kurt	Bird	None	Bird OFS	2 parrots **C**	tree trunks	Isolated	**Field**: parrot **C**, **nesting**, snake	Bastion&S and dune diff	Tree, trunk	Bird OFS	Parrot, Nest/eggs	none	Varied from diorama	9 birds, chameleon, skink	Parrot identical	D2	L		Birds better drawn, in D3 shows habitat.	
Diedo Deon	Bat, butterfly, dog	Tree	All OFS, **Antrop**	**Countryside**: 2 birds, 1 well drawn **C**, hunter **shooting**	Tree, grass, Sun	Bird OFS	**Yard**: bird **C**, beetle, shrew	Yes	None	Birds IS	None	All	None	5 birds, gecko, butterflies	Different	None	L	Greater accuracy in placement of organisms in habitat. Narrative seen. Charismatic to non-charismatic animals, hunting not shown, but few animals seen and no plants.		
Fenech Gareth	Dog, snail, bird, cat, fish	3 trees	All OFS	**Woods**: 6 birds (V-form)	2 trees **C**	Bird OFS	**Field**: bird **C**	Yes	Tree, flower	Bird OFS	none	none	All	9 birds, chameleon, skink	Different	D3	L		Less animals, bird in D3 better drawn	
Galea Charmaine	Snail	2 trees, flowers	All OFS	Bird **C**	None	Isolated, **Antrop**	**Yard**: Bird/Basket **C**, birds/ventilator, gecko	Yes	creeper	Birds IS	None	All	None	4 birds, shrew, beetle	Different	None	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. Prespective show here.		
Incorvaia Thorin	Rabbit, bat, killer whale, snail, crocodile, giraffe, rhino, rooster,	None	N/A	**Field**: 2 birds **flying**, duck **C**, squirrel, hunter **shooting**	Tree	Bird IS	**Yard**: rooster **much larger**, 2 birds **C**, gecko, shrew, beetle	Yes	None	Bird OFS, shrew OFS, beetle OFS	Spider/web	All	None	4 birds, butterflies	Bird similar: D2,D3	None	L		Animals basic throughout, but in context in D3.	
Muscat Ayrton	Cat, cow, ostrich, snail, bird	Trees, flowers, grass	All OFS	**Field**: Snail **C**, ostrich, bull, mouse, dog, cat	2 trees and flowers	All OFS, **Antrop**	**Bastion**: Rat	Yes	Tree **C**	Rat IS	None	All	Rat	Owl, Bat, Weasel, 2 birds, moth.	N/A	D2	L		Animals basic throughout, but in context in D3.	
Muscat Christopher	Pelican, butterfly, duck, starfish	None	N/A	Bird	None	Isolated	No diorama: Duck **C**	Diff	None	Bird OFS	None	none	None	No diorama	Different	None	L		From iconic to very well drawn mallard	
Scerri Matthew John	Parrot	None	N/A	Bird **C**	None	Isolated	No diorama: Duck & Bird **C**	Yard, diff	None	Isolated	N/A	N/A	N/A	No diorama	Different	None	H		From basic birds to very well drawn mallard	
Schembri Harley	Bat, butterfly, cat, spider, fish, rabbit, snail, crab, tadpoles	None	All OFS, **Antrop**	**Garden**: Birds (V), Butterflies **C**	Roses, flowers	Butterflies OFS	**Yard**: 3 birds, gecko, shrew, beetle, butterflies	Yes	creeper, flowers	All IS	None	All	None	3 birds	Different	None	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. Prespective show here. Plants realistically drawn.		
Vella Marie Chloe	Cat, snail, butterfly, hedgehog, octopus	None	N/A	9 Birds (1 in **C**)	None	Isolated	**Field**: 6 birds (2 birds on soil **C**), Chameleon, rabbit	Yes	tree	All IS	Spider	All	None	4 birds, skink	Different	None	H: D2	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. Prespective show here.		
Zahra James	Snail	None	N/A, **Antrop**	**Garden**: none	Tree	Tree IS	**Sand dune**: None	Field, diff	None	N/A	None	N/A	None	All	N/A	D2,D3	L		From iconic snail to sand dune	
Zerafa Enrico	Skeletons of ostrich and human	None	N/A	**Countryside**: bird **C**	Tree	Bird OFS	**Field**: 2 birds **C**, rabbit	Yes	tree	All IS	None	All	None	8 birds, chameleon, skink	Bird similar: D2,D3	None	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. Prespective show here.		

CLASS 5.2

Agius Myron Jose	**Garden**: bird **flying**, bird nesting	4 types trees **C**	Birds OFS, **Antrop**	NI: Flamingo, kingfisher **C**, bird	None	Isolated	No diorama: Owl, hoopoe **C**, bird **flying**	Bastion, no time	None	Isolated	N/A	N/A	None	N/A	Birds similar: D2, D3	D1	H			From woods to isolated birds, knowledge decrement
Azzopardi Christian	Farm: 4 birds, 3 pheasants, duck, snake, cow **C**	2 trees, sunflowers	All IS	**Absent for visit**			**Absent for visit**													
Borg Liam	**Wood**: Lion **C**	7 trees (2 pines)	Lion IS, Sun OFS	**Countryside**: none	9 trees (4 pines) pine tree **C**	Trees IS, Sun IS	**Yard**: 2 butterflies, bird (V-shaped)	Yes	Trees, flowers	Butterflies OFS	Clouds	Door only	Trees different	All animals except butterflies	Almost Identical: D1,D2	D1	L		Still basic organisms but more animals in D3.	
Borg Samira	**Countryside**: None	Tree **C**, glass, flowers	Sun OFS	**Garden**: Parrot, bird **C**, 3 butterflies **flying**	Grass	Birds OFS, Butterflies OFS	**Yard: 3 butterfles & snail**	Yes	Trees, flowers	All OFS, **Antrop**	None	All	Shutter on opposite side	All animals except butterflies	Different	D1	L	Greater accuracy in placement of organisms in habitat. Narrative seen but no perspective, non-charismatic animals.		
Camilleri Christian	NI: 8 birds **flying** (2 types) 2 birds/tree **nesting**, 3 Ants, dog, 2 humans **C**	2 types tree, flower	Birds OFS	**Garden:** 2 pigeons, horse **C**	Tree	Birds OFS, Horse OFS	**Yard**: bird **flying much larger C**, bird/window, beetle, shrew, rooster.	Valley, diff	3 trees	All OFS	Sun, web	Door only	Sizes all different	4 birds, butterflies, gecko	Birds, trees, sun similar: D1,D2,D3	D1	L			All basic, but less animals shown
Cortis Myfanwy	NI: Pheasant, spider, butterfly, dog	6 trees **C**, 2 types of flower	All OFS, **Antrop**	NI: Pelican, 2 birds **nesting C**	2 trees	Birds OFS	**Sand Dune**: bird **flying**, 2birds **C**	Yes	None	All IS	None	All	None	3 birds, reed	Birds similar: D2, D3	D1	L	Greater accuracy in placement of organisms in habitat. Narrative seen but no perspective, non-charismatic animals.		
Sephora Galea	NI: 2 Swans **C**, duck, bird, chick, frog, fish, bee, butterfly, ladybird, mouse, spider.	6 trees, 2 types **C**, reeds, flowers	Isolated, **Antrop**	NI: 6 bird types; pigeon **C**	Flower	Isolated	**Sand Dune**: 2 birds	Yes, prefers drawing from imag	Reed	All IS	None	All	Bird on boat looking ahead	4 birds	Anthropomorphism in D1, Birds in D1&D2 more realistic, more Iconic in D3	None	H			Many organisms in 1st and 2nd to just 2 birds
Gauci Anne Marie	NI: Bird, duck, snake **C**, monkey, fish **C**	Tree	Isolated	NI: 9 birds(V) **flying**, duck, snake	Tree	Isolated	No diorama: butterfly **C**	Sand dune, diff	Flower **C**	Isolated	N/A	N/A	None	N/A	Duck similar	None	L			All iconic but just one animal and plant in D3.
Gauci Mark	**Valley&Field**: 3 types of fish **C**	Flower	3 types Fish IS	**Field**: 3 Birds(V) **flying C**, fish	2 trees	**Anthrop**, Sun OFS	**Field**: None, diff to draw	Yes & Yard	2 types of flower, 1 flower **C**	N/A	Flowers	None	Varied from Diorama	All animals	Field in D1 and D3 very similar. Flowers same	D1	L		Similar, but more plants in D3.	
Lucasenco Catalina	**Garden**: 3 birds **flying**, 1 bird/tree, 2 butterflies **flying C**	2 Pines, 2 green apple, 2 red apple, 2 orange, 5	Birds OFS, Butterflies OFS	NI: 4 birds (V) **flying C**	2 trees, 3 flowers	Flowers OFS, Birds IS	**Yard:** Rooster & 3 birds	Yes	Flowers	Birds OFS, **Antrop(X4)**	None	Rooster & bird in ventilator	Shutter on opposite side	All except birds	Flowers and birds	D1	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. Prespective show here.		
Marchand Fabrice	NI: Bird **flying**, rabbit, elephant **C**, hunters	Flower	Birds OFS, Elephant OFS	NI: Owl **C**	Tree	Birds OFS	**Yard**: bird, beetle, shrew **C**	Yes	None	All IS	None	All	None	5 birds, gecko, butterflies, plants	Different birds	None	VL			All iconic, but less animals in 3rd.
Micallef Joshua	**Field**: Eagle **flying&feeding C**, duck, chicken, swan, fish, donkey, butterfly	2 trees	All OFS	Farm: Swan **C**, eagle **feeding**, donkey	Tree	All OFS, **Antrop**	**Yard:** Rooster **C**, 3 birds, beetle, shrew	Yes	None	Birds IS, Shrew & Beetle OFS	None	All, except rooster	None	2 birds, gecko	Birds similar, Same feeding relationship	None	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen. No prespective show here.		
Mark Mifsud	**Garden**: Eagle **flying**, Parrot **feeding C**, Budgie **flying**, cat, dog, **butterfly&crysalis C**, caterpillar	Tree	Birds OFS	NI: vulture **C**, eagle	None	Birds OFS	**Yard**: Rooster	Bastion, diff	Plants	Rooster OFS	None	All	None	5 birds, gecko, butterflies, beetle, shrew	Birds different, parrot feeding	D1	H			Less animals and ecology from D1 to D3. Knowledge decrement
Mifsud Maxine	**Countryside**: 2 birds **C**, 4 butterflies	8 trees, 10 flowers	Birds OFS, Butterflies OFS	NI: Owl, 2 birds **C**	None	Isolated	**Sand Dune**: 4 birds (2 on sand **C**)	Yes	Reed	Birds on sand OFS	None	All	Bird on boat looking ahead, birds on sand not facing each other	2 birds	Birds similar: D2,D3	D1	L		Basic organism in D1 to better shown birds in D3.	
Mohamed Phyllisianne	**Seaside**: Birds **flying**, bird **nesting**, butterfly, fish, jelly fish, snail, horse **C**, tiger, ladybird,	Tree	All OFS, **Antrop**	**Garden**: 4 butterflies **flying**, sheep, dragon **C. Shows Sea.**	Tree, grass	All OFS	**Sand dune**: bird	Yes	Reed	Bird IS	None	All	Bird on boat looking ahead	5 birds	Birds similar	D1	VL			Less organisms shown
Muscat Melchior	**Seaside**: 4 birds, bird **nesting**, butterfly **flying**, dog **C**, jelly fish, fish, fishermen	Tree	All IS	**Countryside**: duck **C**, turtle, horse	Tree	Isolated	**Field**: Bird **C**, 2 rabbits	Yes	Tree	All OFS	None	None	Varied from Diorama	9 birds, chameleon, skink	Animals similar	D1	VL			Organisms in context, to fewer in less well shown habitat
Powell Matthew	**Countryside**: Green Finch **C**	Plants	Birds OFS	NI: Pelican **C**	3 Trees	Birds OFS	**Field**: 2 Birds **C**, rabbit	Valley, diff	Tree	All IS	None	All	Varied from Diorama	8 birds, chameleon, skink	Different birds	D1	VL: D2,D3		One well drawn bird in D1 to more but more basic animals	
Scerri Erika	**Garden**: 2 ducks **C**, 6 birds (V) **flying**, bird **nesting**, 4 fish	2 Trees (apple), 2 flowers, wild plant	All IS	NI: Owl, duck, flamingo, Ostrich, 2 birds **C**	None	Isolated, **Antrop**	**Sand dune: 3 birds C**	Yes	None	Isolated	None	N/A	No diorama	N/A	Birds similar	D1	L: D2, D3			Colourful, animals in habitat in D1 to poor drawing in D3.
Schembri Claire	**Garden**: 2 girls	2 trees	Sun OFS	**Garden**: her and bro	2 trees	Isolated	**Sand Dune**: Duck, lizard **C**, rat	Yes	2 flowers	Isolated	None	N/A	No diorama	N/A	Similar: D1, D2	None	VL	Focus on separate animals from just humans		
Smith Benjamin	**Beach**: Duck, bird, dog **C**, hamster, cat	Palm	All OFS, **Antrop**	Crow **C**	Tree	Isolated	**Yard: Rooster C**	Sand dune, diff	creeper	All IS	None	All	None	5 birds, gecko, butterflies, beetle, shrew	Different birds	None	L: D3	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen, but limited prespective shown here.		
Xuereb AJ	Seaside: birds, 4 fish, shark, octopus **C**	Algae	All OFS	**Absent for visit**			**Absent for visit**													
Zahra Jean Paul	**Seaside**: Eagle, birds(V), fish, people **C**	Tree	Sun OFS	Crow **C**	None	Isolated	**Field**: hedgehog	Yes	Flowers **C**, wild plants	Flowers OFS	Hedgehog, flowers	None	Varied from Diorama	All animals & plants	Different	D1	L	Greater accuracy in placement of organisms in habitat, more focused on one habitat		

CLASS 5.3																				
Bartolo Lenise	**Countryside**: 2 birds **flying**, butterfly **flying C**, snail, cat	2 cherry trees, 9 flowerds (4 types)	Animals OFS, **Antrop**	**Countryside**: 3 butterflies **flying C** (2 types), Bird **flying**	2 Cherry trees, flowers	Animals OFS	**Yard**: 2 butterflies **C**, rooster	Yes	creeper, flowers	Flowers, butterflies & rooster IS	None	All, except door	None	5 birds, gecko, beetle, shrew	Almost identical: D1,D2	All	L:D3	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen, but limited prespective shown here.		
Borda Aaron	**Garden:** bird **nesting**, 3 squirrels **C**	2 trees	Animals OFS	Bird	None	Isolated	**Yard**: butterfly, gecko, rooster **much larger**	Sand dune, diff	Flowers	Animals OFS	Broken egg	All	Rooster looking other way, broken EGG beneath it (misstook for hen)	5 birds, beetle, shrew	Birds similar	D1	L			Very colourful D1 to less elaborate D3 with fewer organism
Borg Maylea	**Garden:** butterflies	Tree, flowers, grass	Butterflies OFS	**Garden**: 2 Butterflies **flying C**, 2 bees **flying**	2 tree types, 2 flower types	Animals OFS, **Anthrop: Sun**	**Field**: Rabbit **C**, rat lizard	Yes	None	Animals OSF	Rat	All, except skink	**Anthrop: Rabbit**	10 birds, chameleon	Different animals	D2	VL		Very similar, iconic organisms	
Briffa Ethan	**Garden**: Parrot/cage, pigeons/tree **C**, bird flying, bird/grass	2 Tree, sunflower, grass	Animals OFS	**Garden**: bird flying, bird/tree, snail, grasshopper, snake	Tree	All IS	**Yard**: 2 birds	Yes	Trees, flowers	All IS	None	Birds, tress	Flowers on opposite side	5 birds, gecko, butterflies, beetle, shrew	All organisms	D1	L	Greater accuracy in placement of organisms in habitat, more focused on one habitat		
Bugeja Nathan	Rabbit **C**	None	Isolated	Bird **C**	None	Isolated	**Sand dune**: Bird on boat **C,** bird on stone	Yes	None	Birds IS	None	All	Bird on boat looking toward front	4 birds	Different birds	D1, D2	H:D2	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen, but limited prespective shown here.		
Buhagiar Piyawat	**Forest**: Adult snake **C**, 2 juveniles and 1 hatching	2 tree types, 2 flower types	All OSF, **Anthrop: Sun**	**Wood**: flying bird, butterflies, humans	3 Trees, flowers	All OFS	**Yard**: 2 birds	**Yes**	None	Birds IS	None	Birds	Only part of setting	5 birds, gecko, butterflies, beetle, shrew	Thai Boy: difference in experience with animals	D1	H	Greater accuracy in placement of organisms in habitat, more focused on one habitat		
Chetcuti Dale	**Garden**: Cat **C**, bee **flying,** 2 gold fish	Apple Tree, 1 tulip, 2 daffodils, wild flower	All OSF, **Anthrop: cat, bee**	**Garden:** Butterflies **flying C**, 3 bees **flying,** 2 gold fish, cat, mouse	trees, 3 2 apple tulips, 2 daffodils, grass	Animals OFS, **Anthrop: Sun, bees**	**Yard:** Rooster **C**, rat, shrew, gecko, rabbit. Anthropomorphism: rabbit, rooster	Yes&field	Flower	Animals OSF	Rat, Rabbit	Shrew, gecko only	Varied from diorama	5 birds, beetle, butterfly	Bees, cat similar: D1, D2	D1, D2	L		Iconic organisms shown in all, colour in D1&D2	
Chircop Francesca	**Garden:** birds **flying**, bird/tree, 2 butterflies **C**, girl, squirrel	2 tree, 2 flowers, grass	Butterflies OFS, Flowers OFS	**Garden:** Bird **flying**, 2 types of Butterflies **flying C**	Apple tree, flower, grass	**Anthrop: Sun**	**Yard**: gecko	Yes&field	Grass	Gecko IS	None	Only gecko	Varied from diorama	5 birds, beetle, butterflies, shrew	Similar: D1, D2	D1, D2	L			From colourful D1&D2 to colorless D3 with only a gecko& grass
De Giorgio Lee Harvey	2 Parrots **C**, monkey	None	Isolated	**Absent for visit**			**Absent for visit**													
Farrugia Kimberly	**Garden**: dog **C**	6 types of flowers, grass	Dog OFS	**Forest**: Robin **flying (larger)**, butterfly **flying**	3 trees	Animals OFS	**Yard**: none	Yes	plants	N/A	None	Only plants	Varied from diorama	5 birds, beetle, butterflies, shrew, rooster, gecko	Different	D1, D2	VL			Less animal representation in D3
Gatt Kurt	**Garden**: Bird **flying C**, bee, rabbit, 2 persons **C**	Tree, flowers, grass, sunflower	Animals OFS, **Anthrop**	**Garden**: eagle **C**, pigeon, sparrow, owl, cat, bird **flying** .	2 Trees	Animals OFS	**Yard**: rooster, 2 birds **C**, bird **flying**, owl, duck, spider, butterfly, 2 rats,	Yes	2 Flowers	Most animals IS, except butterfly	Clouds, sun	Only 1 bird	Aspects of different dioramas shown, **Anthrop**	N/A	Animals similar	D1, D2	L	Enhancement of existant knowledge		
Gauci Katya	**Garden**: 4 goldfish **C**, cat	4 flowers, 2 types of tree, grass	Goldfish OFS, Flowers OSF	**Garden**: Bird, butterfly **flying C**, bees **flying**	2 trees, 3 flowers, grass	Animals OFS, **Anthrop: Sun**	**Field**: Rabbit, Bird **C**	Yes	None	Rabbit IS, Bird OSF	None	Only rabbit	Varied from diorama, **Anthrop**	9 birds, chameleon, skink	Similar trees, flowers: D1, D2	D1, D2	L			Reduced animal representation and habitat
Giordmaina Gerald	Pet shop: 3 Birds **flying C**, 3 fish	Flower pot	Animals OFS	Pet shop: 2 Birds, 3 fish	2 flowers	Animals OFS	**Sand Dune**: 2 birds	Yes	Reed	All IS	None	All	Boat colour	Flying bird, bird/reed, 2 birds on sand	Trees and flowers similar	D1, D2	L		Basic iconic representation in all	
Grech Maxim	**Countryside**: bird **flying C**, rabbit, bee, ants	Tree, Sunflower, 3 types of flower	Animals OFS	**Seaside**: bird **flying** , 2 types of butterflies **flying**, 4 fish, whale **C**	None	Animals OFS	**Field**: Rabbit, Bird **C**	Yes	Tree	Birds IS	Sun	Only 1 bird	Varied from diorama	9 birds, chameleon, skink	Birds similar	All	L		Basic iconic representation in all	
Micallef Andrew	**Forest**: Eagle **flying C**, Taucan **C**, frog, crab, cheetah, snake, cobra,	4 trees, grass	Spider&web, OFS	**Park**: bird **flying**, moth **flying C**, snake **C**, duck, fish	Flower, tree	Animals OFS	**Bastion:** bat **flying**, bird, owl **C**, rat	Yes	Weed	Owl OFS	None	All	Owl eyes only shown	Moth, weasel, bird	Birds similar	All	H	Enhancement of existant knowledge		
Muscat Jeremy	**Seaside**: 5 ducks **(large)**	2 types of tree, mushrooms	Ducks OFS	**Cliffs**: Eagle **C**, vulture, turtle dove.	None	Birds IS	**Sand dune**: Bird on boat **C**, 4 birds, bird **flying**	Yes	None	Stone bird OFS	duck opening bivalve	All	Bird on boat looking toward front	Bird on reed	Birds similar, Vulture realistic. Rock strata in Malta	All	H	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen and some prespective shown here.		
Potelli Liam	**Aquarium**: 2 sharks **C**, goldfish, dolphin, divers	Algae	Fish OFS	NI: Robin, bird **C**	Tree	Robin OFS	**Yard**: bird **flying**, beetle, shrew **C**	Yes	2 trees	Shrew OFS	Flying bird	All	Bird on shutter facing opposite direction	4 birds, rooster, gecko	Different birds	D1	H			Reduced animal representation and habitat
Saliba Kyle	Seabed: shark **C**, frog eating fish	None	Animals OFS	**Absent for visit**			**Absent for visit**									D1	L			
Sant Clayton	**Waterfall**: 2 Duck **flying**, 2 ducks in water **C**, 2 fish	None	Animals IS	**Mountains**: Duck **flying&feeding C**, duck **feeding C**, snake, bat **flying**	Tree, grass	Animals OFS	**Bastion**: bat **flying** , bird, owl **C**, rat	Yes	Tree	Owl OFS	None	All	Own eyes only shown, **Anthrop**	Moth, weasel, bird	Birds similar	All	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen and some prespective shown here.		
Scerri Mark	**Park**: bird **flying**, duck, squirrel, 2 butterflies **flying C**	2 apple trees, 2 flowers	Butterflies OFS, Flowers OFS, **Antrop**	**Seaside**: Pelican **C**, 2 sordfish, starfish	None	Fish OFS,	**Bastion**: bat **flying C**, birds/tree, bird **flying C**, owl, rat, weasel, moth	Yes	2 tree, palm		Bat, moth, weasel & rat OFS	All	None, **Anthrop(X3)**	None	Different birds	D1	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen, but limited prespective shown here.		
Tonna Melchior	**Woods**: bird **C**, snake, dog	Tree	Snake OFS	NI: Pelican **C**, robin	Apple tree	Birds OFS	**Sand dune**: Bird on boat **C**, bird **flying C**, 4 birds	Yes	Reed	Birds on sand & stone OFS	None	All	Flying bird in opposite direction, **Anthrop: boat**	None	Birds similar	D1, D2	L	Increased accuracy in habitat representation, greater accuracy in placement of organisms in habitat. Narrative seen, but limited prespective shown here.		
63 total **1 downs syndrome** **1 refused** **4 absent for visit** **57 participants**																		**27/57=47%**	**16/57=28%**	**14/57=25%**

Features that pupils wished to draw

Class Task	*Cases*	*Pre-diorama*	*Cases*	*Diorama*	*Cases*
Jelly fish	1	Cat	1	Bird	5
Squid	1	Dog	1	Chameleon	1
Starfish	1	Eagle	1	Weasel	4
Cats	11	Total	3	Rat	1
Bees	2			Butterflies	1
Birds	6			Rooster	1
Horse	4			Shrew	1
Elephant	2			Beetles	1
Dolphin	3			Gecko	1
Sea Lion	1			Snails	1
Butterfly	1			Animals	3
Frog	1			Total	20
Rabbit	2				
Crab	1			Flowers	1
Eagle	1			Trees	1
Sea Horse	1			Vine	1
Dog	11			Sea weed	1
Sheep	1			Total	4
Parrot	1				
Ants	1			Wall	1
Squirrel	2				
Owl	1				
Fish	2				
Rabbit	1				
Rooster	1				
Whale	2				
Turtle	1				
Panda	1				
Snake	2				
Beaver	1				
Tiger	1				
Total	68				
Grass	2				
Tree	2				
Plants	1				
Flower	2				
Total	7				